

North Pacific Albacore Stock Status and Conservation Advice

Report of the ISC – Albacore Working Group
Stock Assessment Workshop (2006)



P. R. Crone
NOAA Fisheries
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, CA 92037
USA

Presentation Outline

- ✦ **Working Group history**
- ✦ **Stock assessment (2006)**
 - Fishery-related 'statistics'
 - Model
 - Input data
 - Analysis (Results)
 - Conclusions

ISC – Albacore Working Group

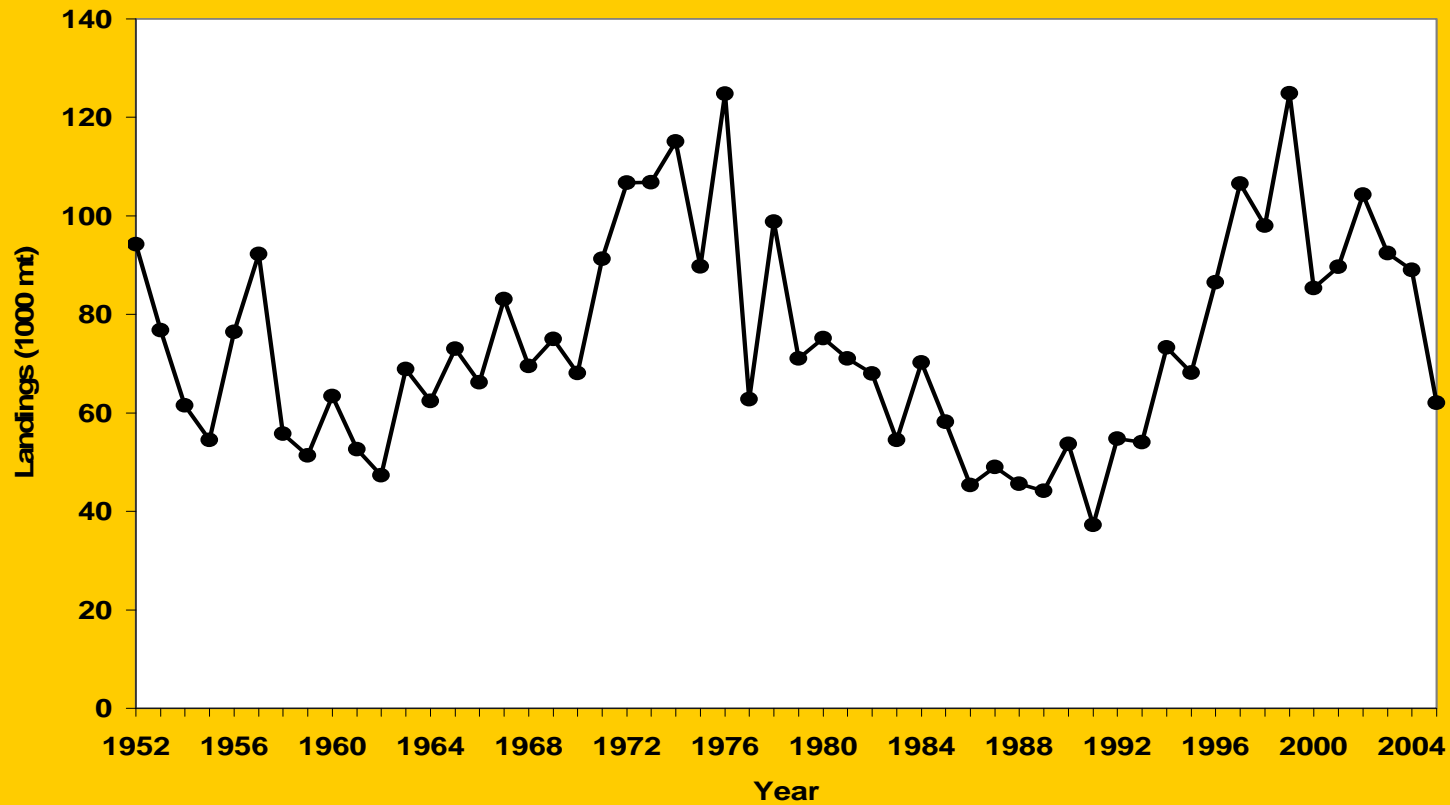
- ✦ Began informally in mid-1970s ... *North Pacific Albacore Workshop*
- ✦ Several nations/institutions 'participate'
 - USA, Canada, and Mexico (EPO)
 - Japan, Taiwan, and S. Korea (WPO)
 - IATTC and SPC
- ✦ For the most part, first 'reviewed' assessment was in 2001
- ✦ Some collaborative research studies, but mostly independently conducted 'albacore' projects, e.g., ...

Fishery-related Statistics

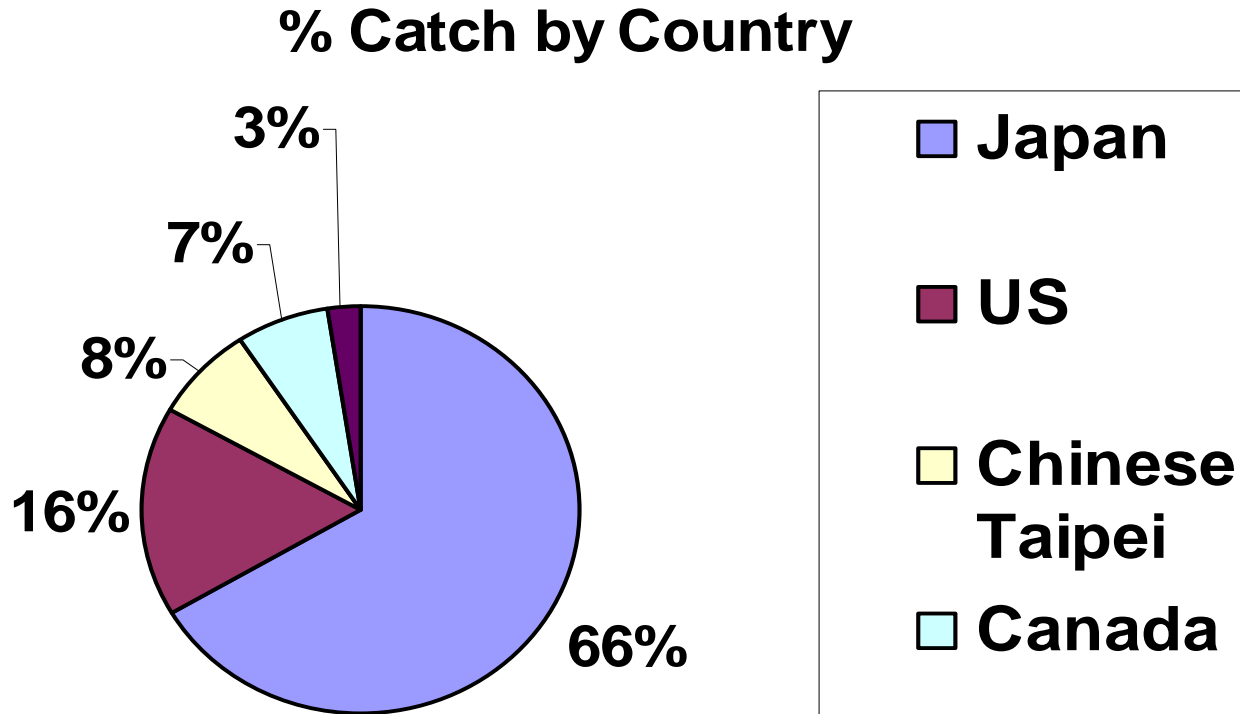
Sampling Programs (Data Base Catalog)

- ◆ Category I – Total landings (round weight, mt) and total nominal effort in number of active vessels
- ◆ Category II – Catch and nominal effort data from logbooks ($5^{\circ} \times 5^{\circ}$ area for longline data and $1^{\circ} \times 1^{\circ}$ for other fisheries)
- ◆ Category III – Size composition (length or weight distributions)

Fishery-related Statistics

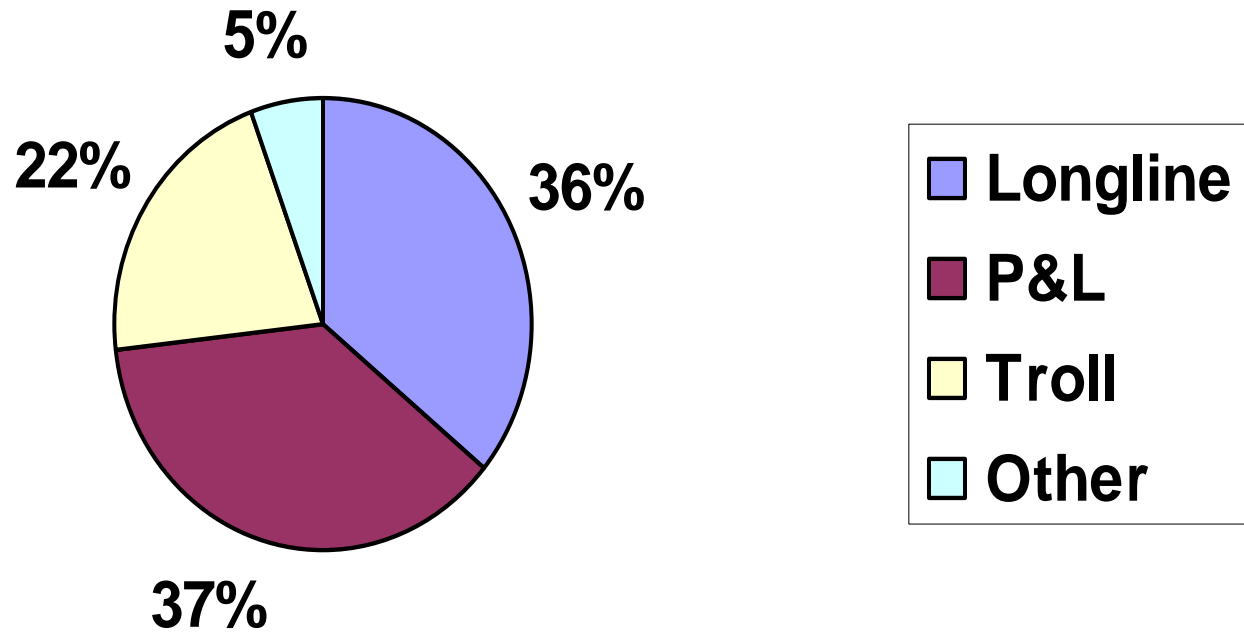


Fishery-related Statistics



Fishery-related Statistics

% Catch by Gear

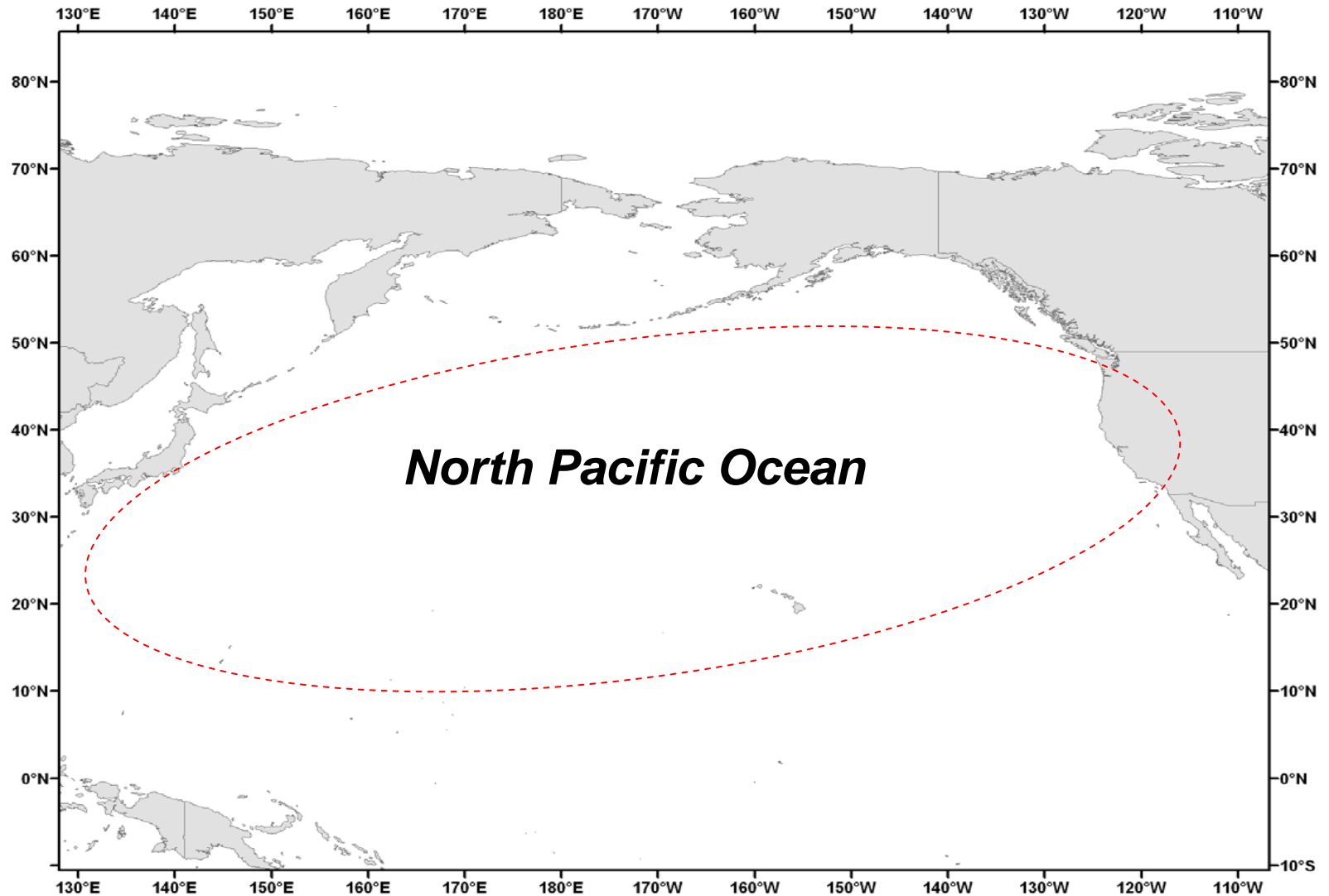


Model

✦ VPA approach

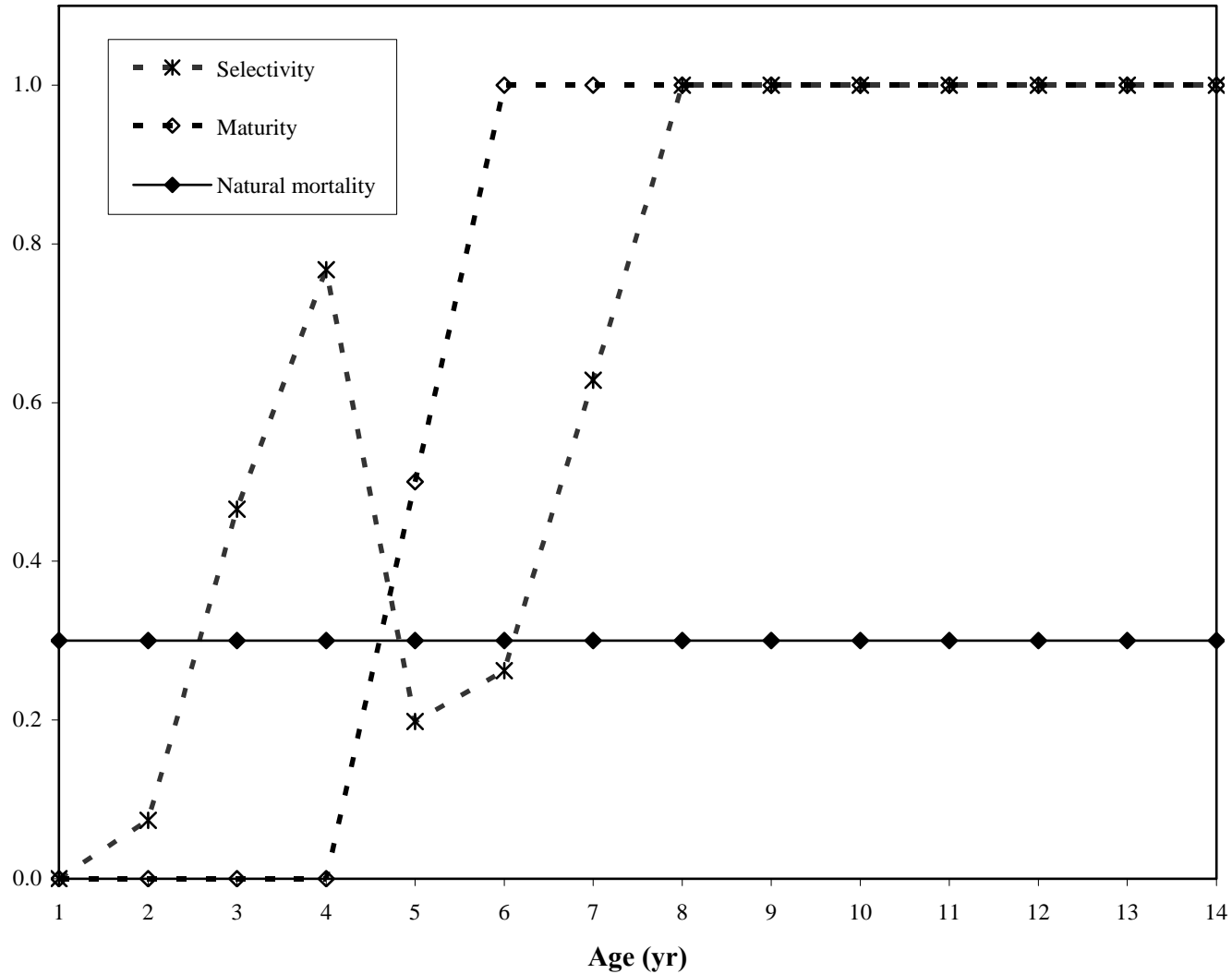
- 'VPA-2BOX' platform (Clay ...)
- Based generally on 'ADAPT' framework (Stratis, Ray, Joe, Victor ...)
- Backward-simulation using catch-at-age time series
- Maximum likelihood estimation (ADMB coded)
- Statistical \equiv CPUE indices
- Pluses / minuses of VPAs

'Stock structure' Assumption



'Pop Dy' Assumptions

Proportion



Input Data

- ✦ **Catch-at-age time series**
 - Substantial changes from last assessment (2004)
- ✦ **Eastern Pacific Ocean (USA, Canada, Mexico)**
 - Sample data from USA and Canada
 - Age compositions largely based on age-slicing methods
 - USA longline age composition based on MULTIFAN
- ✦ **Western Pacific Ocean (Japan, Taiwan, S. Korea)**
 - Sample data from Japan and Taiwan
 - Age compositions based on age-slicing and MULTIFAN

Input Data

Catch-at-age (no. in 1,000s)

YEAR	AGE (yr)									TOTAL
	1	2	3	4	5	6	7	8	=9	
1966	0	129	2,022	1,118	2,412	261	145	52	41	6,180
1967	0	210	2,293	1,552	2,820	579	171	97	72	7,794
1968	0	92	3,268	1,422	1,118	763	254	97	39	7,053
1969	1	2,046	2,584	1,232	2,493	197	191	194	53	8,990
1970	0	282	3,390	2,220	1,321	410	101	71	61	7,856
1971	0	208	4,634	2,424	2,831	388	175	70	81	10,810
1972	0	4,030	3,514	4,646	2,348	270	118	92	60	15,078
1973	1	2,583	3,619	1,531	4,030	743	141	90	74	12,812
1974	0	1,128	4,483	5,653	1,538	754	153	57	96	13,863
1975	0	828	5,222	2,912	1,907	264	111	78	259	11,581
1976	0	2,325	4,937	5,767	2,766	285	165	106	186	16,538
1977	0	741	2,919	1,955	1,106	426	132	91	160	7,531
1978	2	5,931	2,125	4,729	1,018	387	185	45	83	14,505
1979	0	580	1,215	3,623	1,257	265	190	101	68	7,300
1980	0	2,518	2,830	3,160	801	311	110	87	97	9,916
1981	4	898	1,509	2,854	1,095	450	270	106	115	7,301
1982	78	599	1,949	3,408	435	255	200	213	134	7,272
1983	2	1,182	2,552	2,306	232	186	196	146	141	6,945
1984	5	1,111	4,571	3,031	241	177	126	131	156	9,550
1985	2	318	1,235	2,776	641	118	166	100	325	5,681
1986	0	794	906	2,461	204	128	127	90	131	4,840
1987	1	265	2,155	1,296	474	314	176	102	169	4,953
1988	4	133	1,529	1,156	270	606	223	161	181	4,264
1989	106	377	316	1,335	1,012	276	246	133	158	3,959
1990	109	317	239	1,151	1,606	641	113	213	247	4,635
1991	78	678	1,747	335	339	263	155	119	271	3,984
1992	1	332	2,350	1,664	662	360	150	151	156	5,826
1993	0	485	1,090	1,971	793	202	201	116	293	5,151
1994	28	669	1,575	2,355	1,077	654	206	97	136	6,798
1995	2	496	1,310	3,152	294	310	564	116	119	6,362
1996	8	494	3,938	2,294	603	396	554	477	105	8,869
1997	0	2,453	1,431	4,451	817	124	476	620	391	10,764
1998	0	1,105	4,036	1,568	1,880	302	213	379	282	9,766
1999	77	816	3,761	5,797	757	478	477	185	308	12,656
2000	0	1,231	1,852	2,739	923	415	450	435	247	8,292
2001	4	1,470	4,370	1,396	1,153	410	451	277	338	9,869
2002	0	1,447	7,396	3,141	439	226	381	209	222	13,461
2003	0	3,054	3,619	3,008	709	306	250	181	194	11,321
2004	30	210	4,411	4,363	282	452	332	130	44	10,253
2005	1	2,382	1,547	2,318	305	171	437	189	69	7,418
TOTAL	543	46,948	110,447	106,273	47,010	14,522	9,484	6,404	6,365	347,996

Input Data

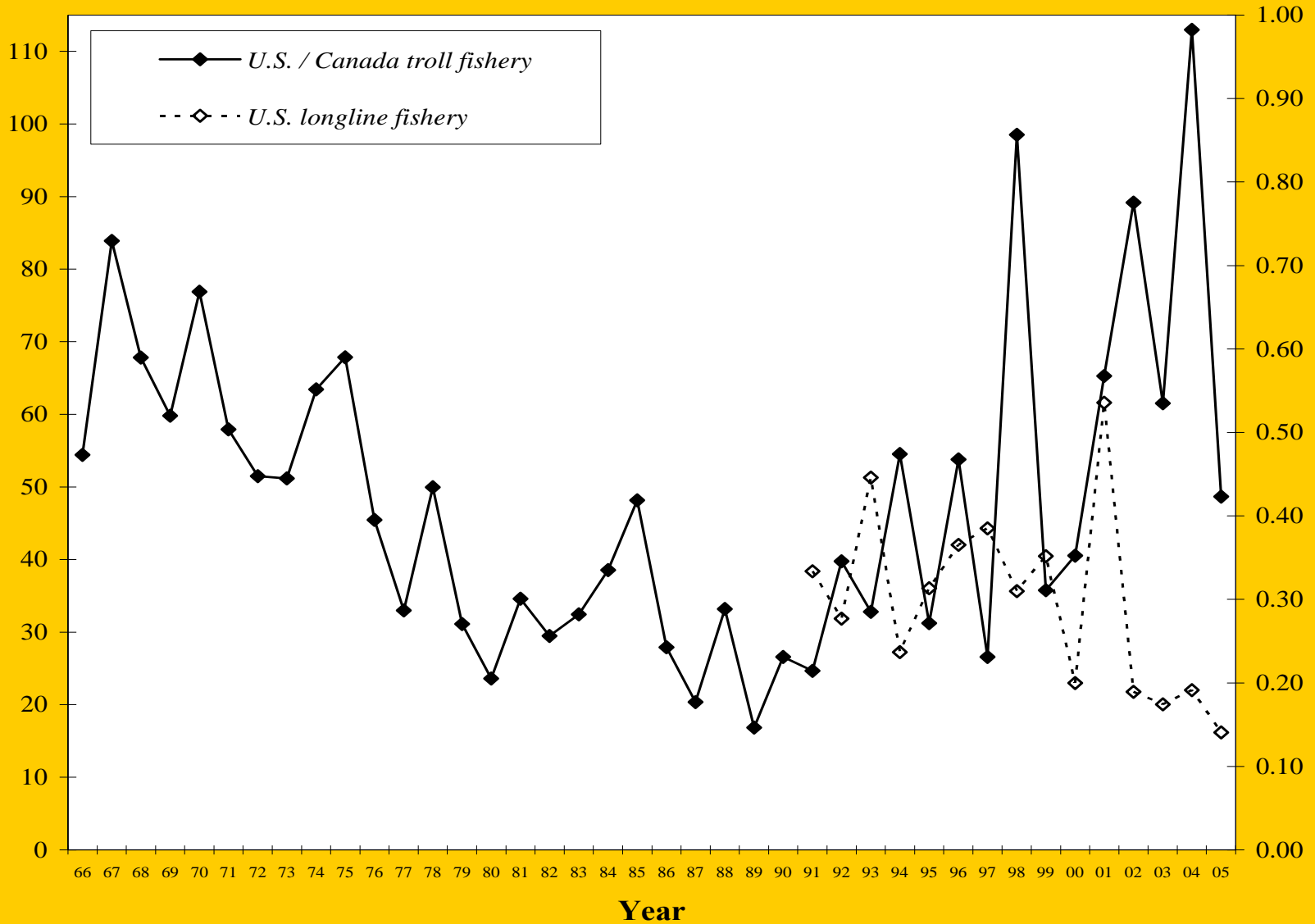
- ◆ Abundance (CPUE) indices (17 total)
 - Substantial changes from last assessment (2004)
 - USA/Canada troll (age-specific for ages 2,3,4,5)
 - USA longline (age-aggregated)
 - Japan pole-and-line (ages 2,3,4,5)
 - Japan longline (3,4,5,6,7,8,9+)
 - Taiwan longline (age-aggregated)

Input Data

CPUE Indices (age-aggregated)

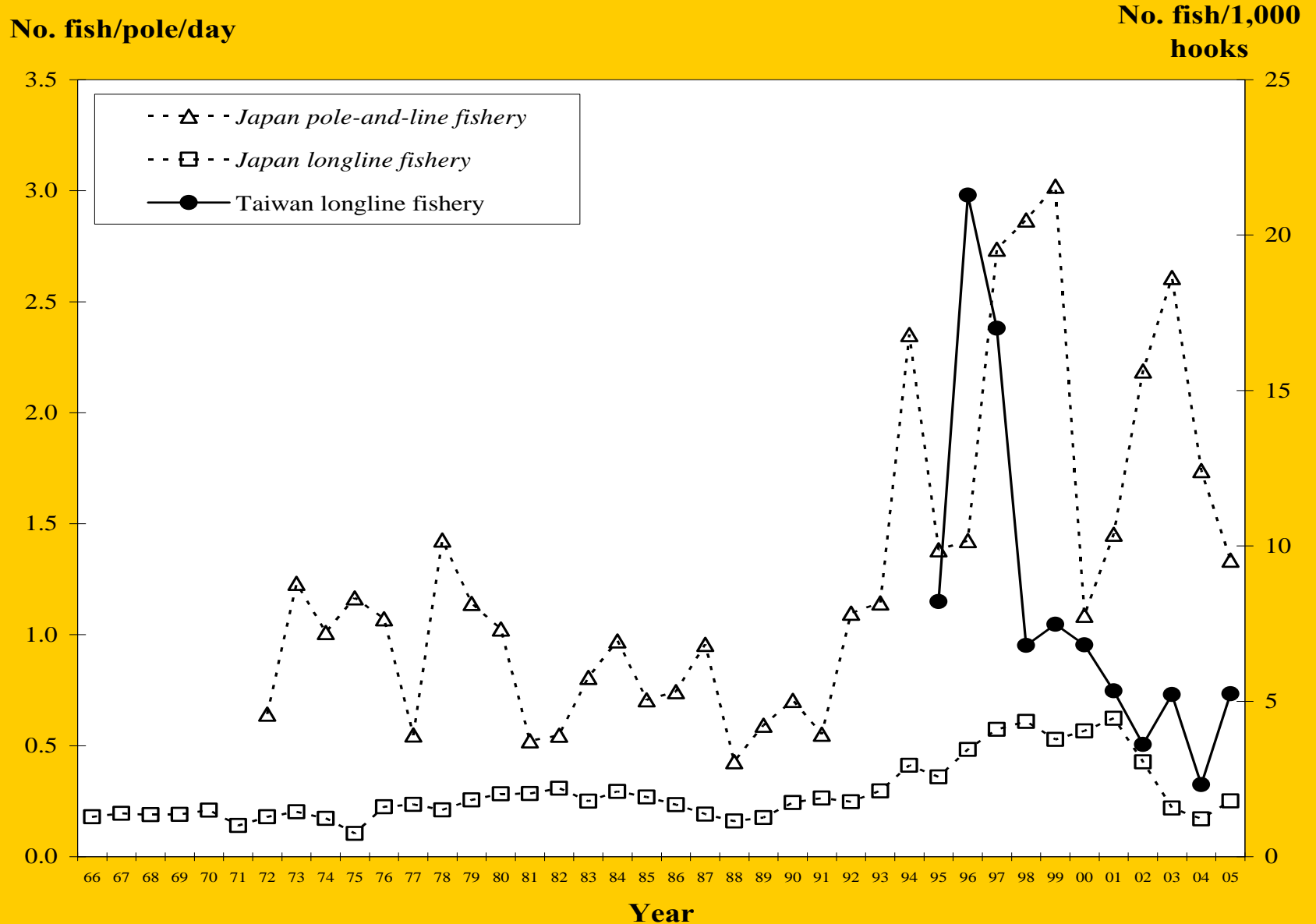
No. fish/day

No. fish/1,000
hooks



Input Data

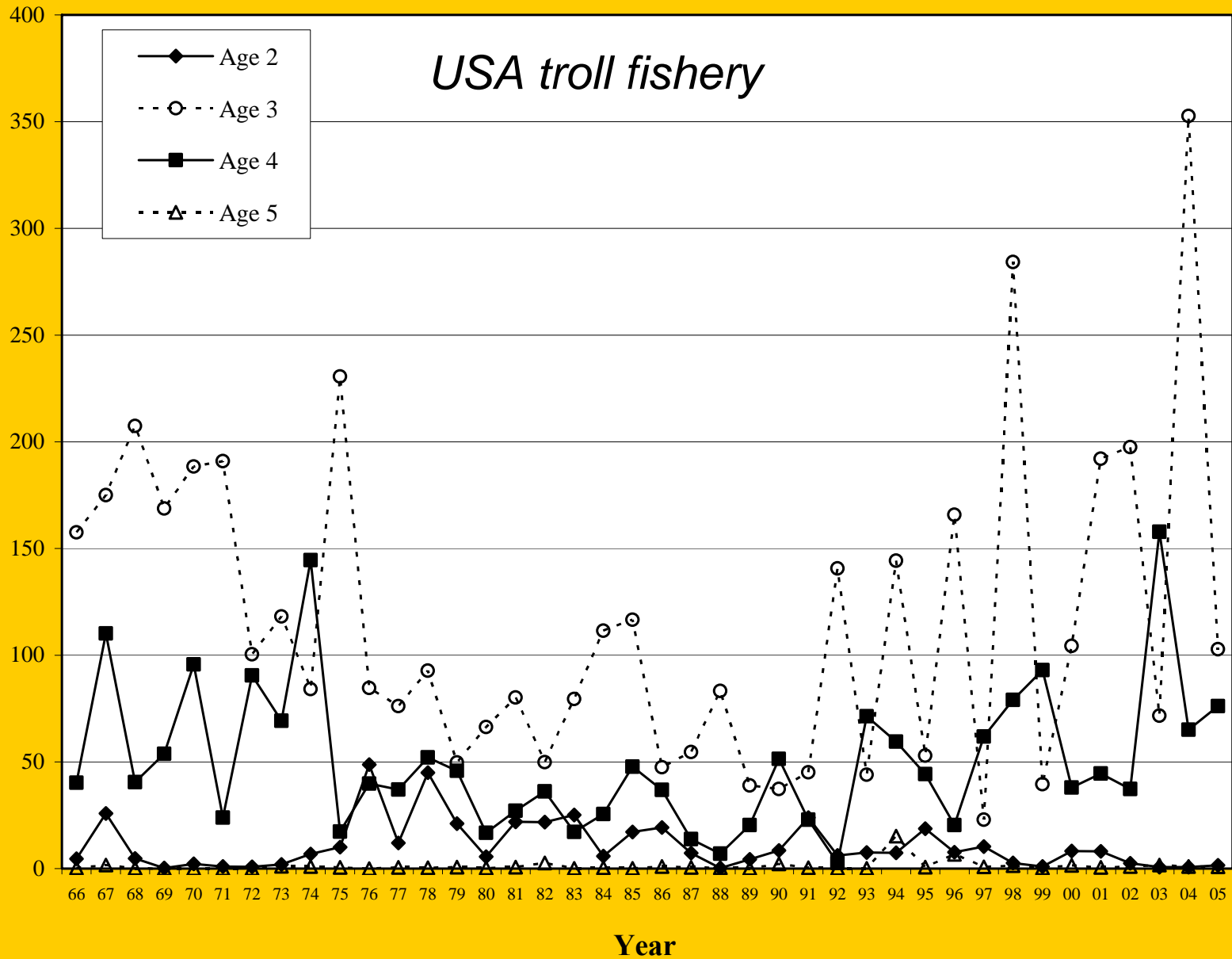
CPUE Indices (age-aggregated)



Input Data

CPUE Indices (age-specific)

Age-specific
abundance index



Analysis

- ✦ Considerable work (model scenario development and sensitivity analysis) prior to the Meeting (December 2006)
- ✦ In total, 15 (candidate) model 'scenarios' were tabled, refined, and reviewed by the ISC-ALBWG
- ✦ Model Scenario 'D1' was chosen as the 'final' model
- ✦ Essentially, similar (final) model as assessment in 2004

Results

Recruitment

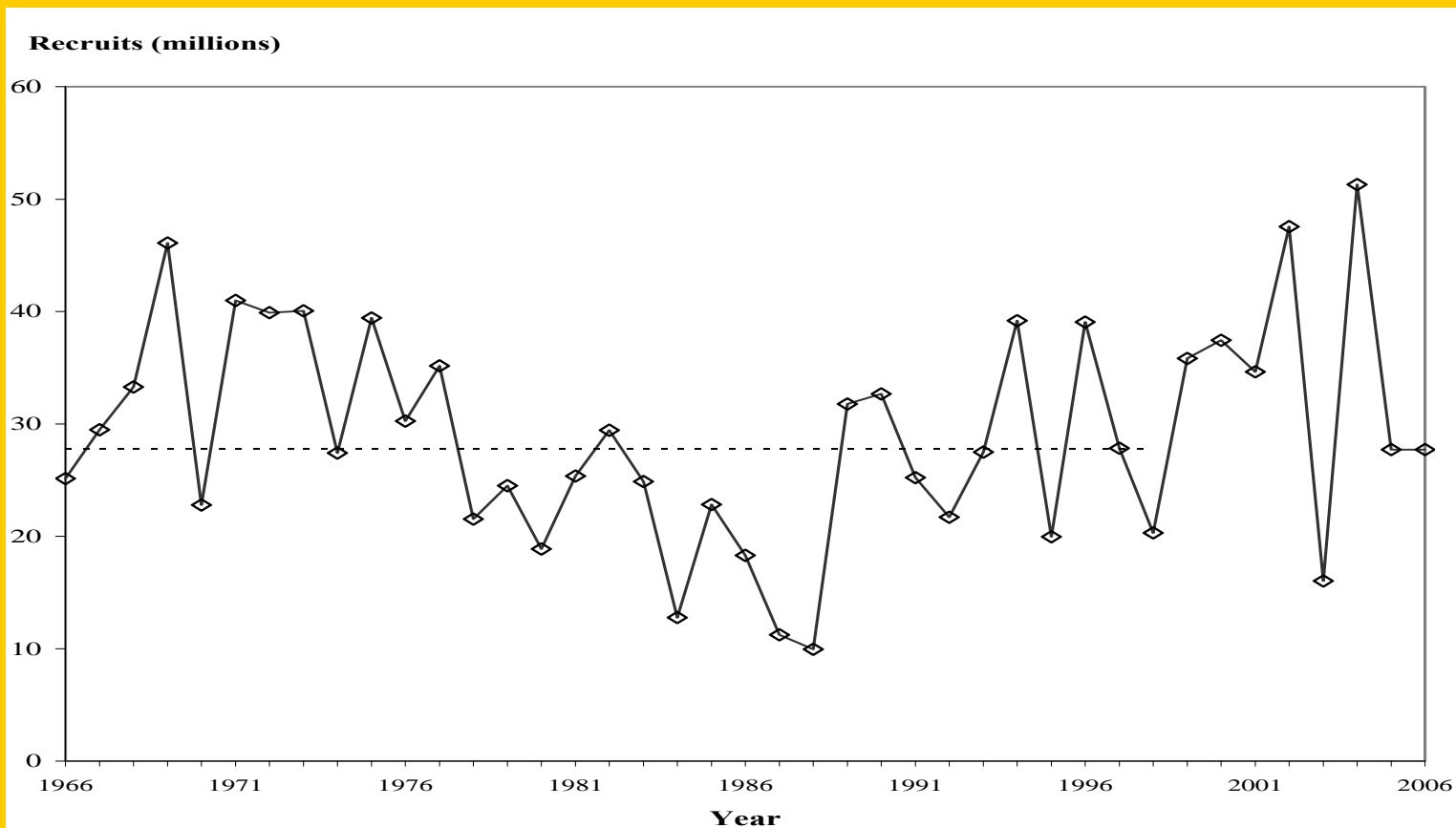
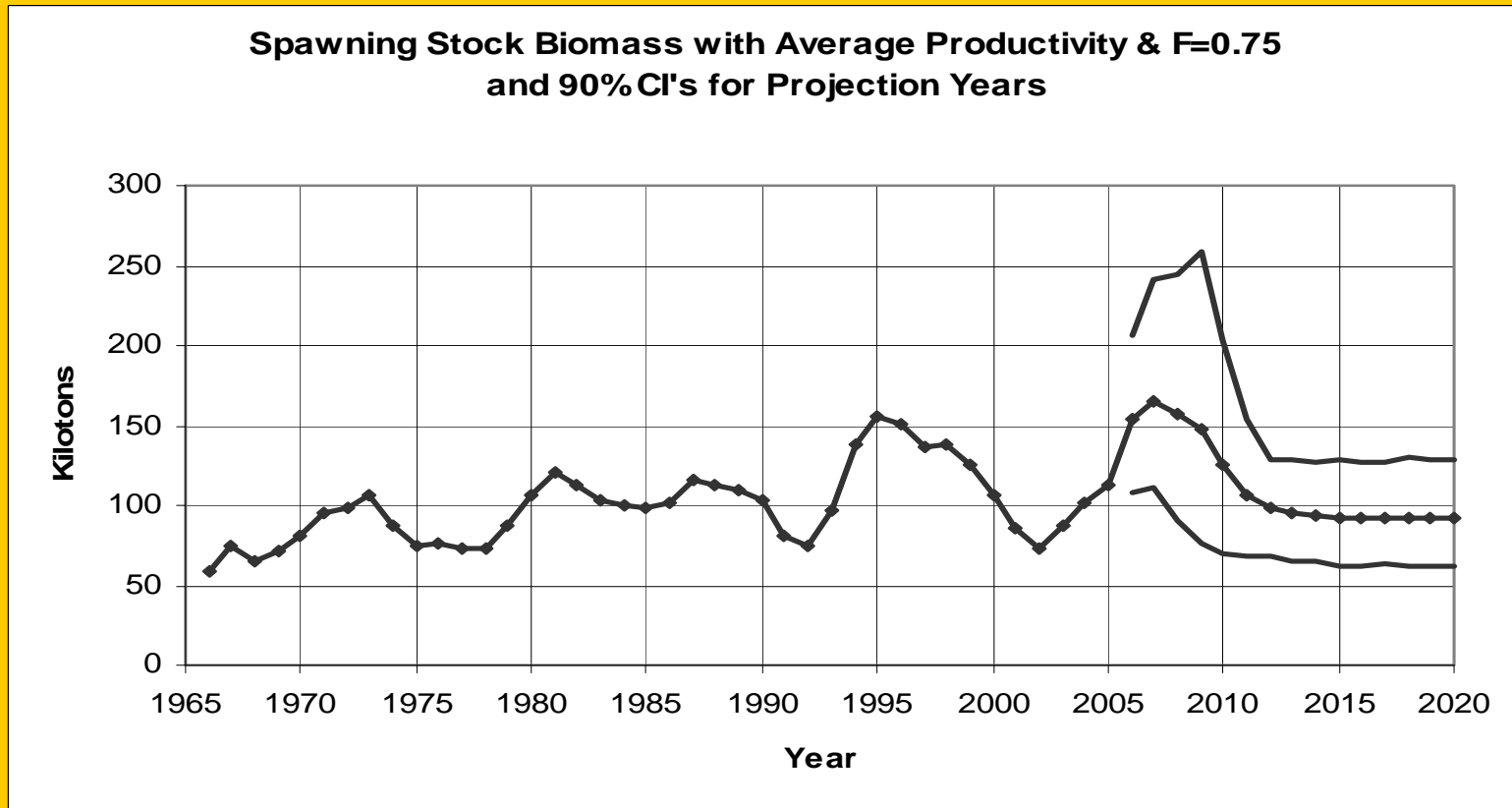


Figure 7. Recruitment (age-1 fish in millions) time series of North Pacific albacore generated from Model D1 (1966-98). Mean (1966-98) recruitment is presented as horizontal dashed line. Figure in 2005 and 2006 were derived from the mean recruitment.

Results

Spawning Stock Biomass



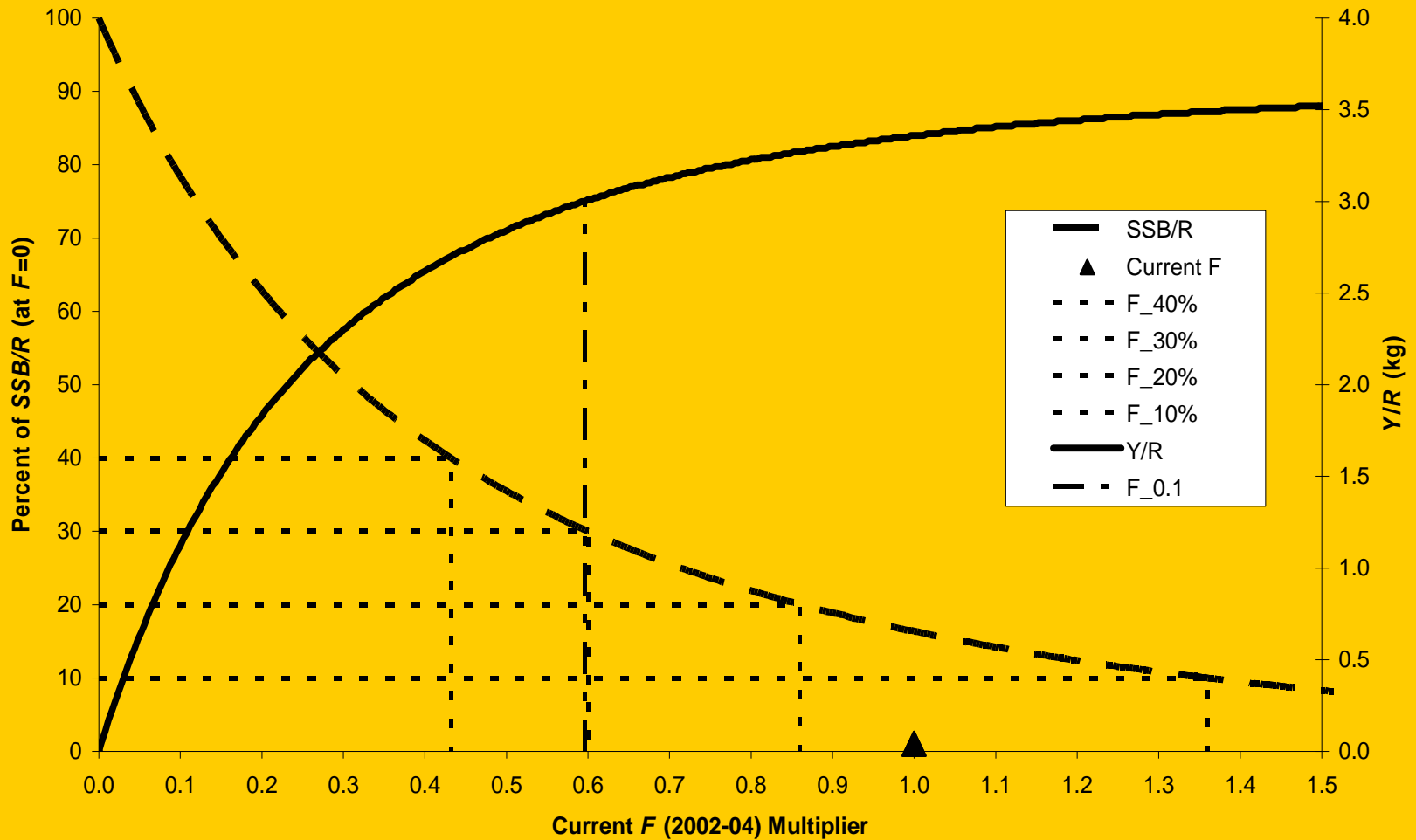
Results

Projections and Biological Reference Points

- ✦ 2004 uncertainty analysis based on 4 model configurations:
 - 'Low productivity' / 'Low F'
 - 'Low productivity' / 'High F'
 - 'High productivity' / 'Low F'
 - 'High productivity' / 'High F'
- ✦ 2006 single productivity period and single current F

Results

Projections and Biological Reference Points



Results

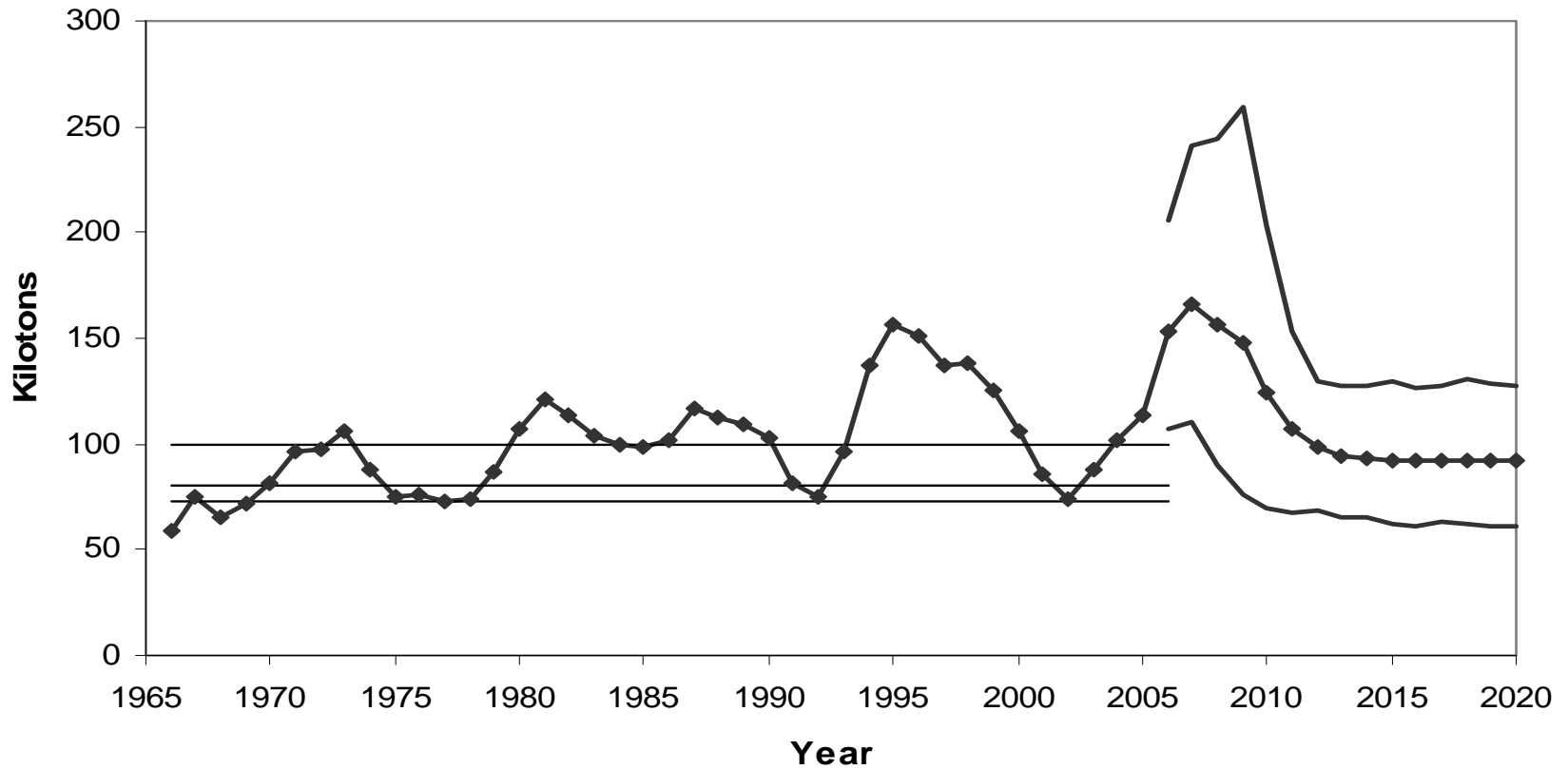
Projections and Biological Reference Points

Candidate Target Reference Points	Target F (yr^{-1})	Ratio of Current F to Target F	MSY Proxy (1,000 mt)	SSB_{MSY} Proxy (1,000 mt)
$F_{40\%}$	0.32	2.31	75	226
$F_{35\%}$	0.38	1.97	79	198
$F_{0.1}$	0.45	1.68	83	171
$F_{30\%}$	0.45	1.67	83	169
Candidate Limit Reference Points	Limit F (yr^{-1})	Ratio of Current F to Limit F	Equilibrium Catch (1,000 mt)	Equilibrium SSB (1,000 mt)
$F_{20\%}$	0.65	1.16	91	113
F_{Max}	2.07	0.36	100	10
$F_{SSB-\text{Min}}$	0.81	0.93	94	83
$F_{SSB-10\%}$	0.70	1.07	92	102
$F_{SSB-25\%}$	0.66	1.14	91	110

Results

Projections and Biological Reference Points

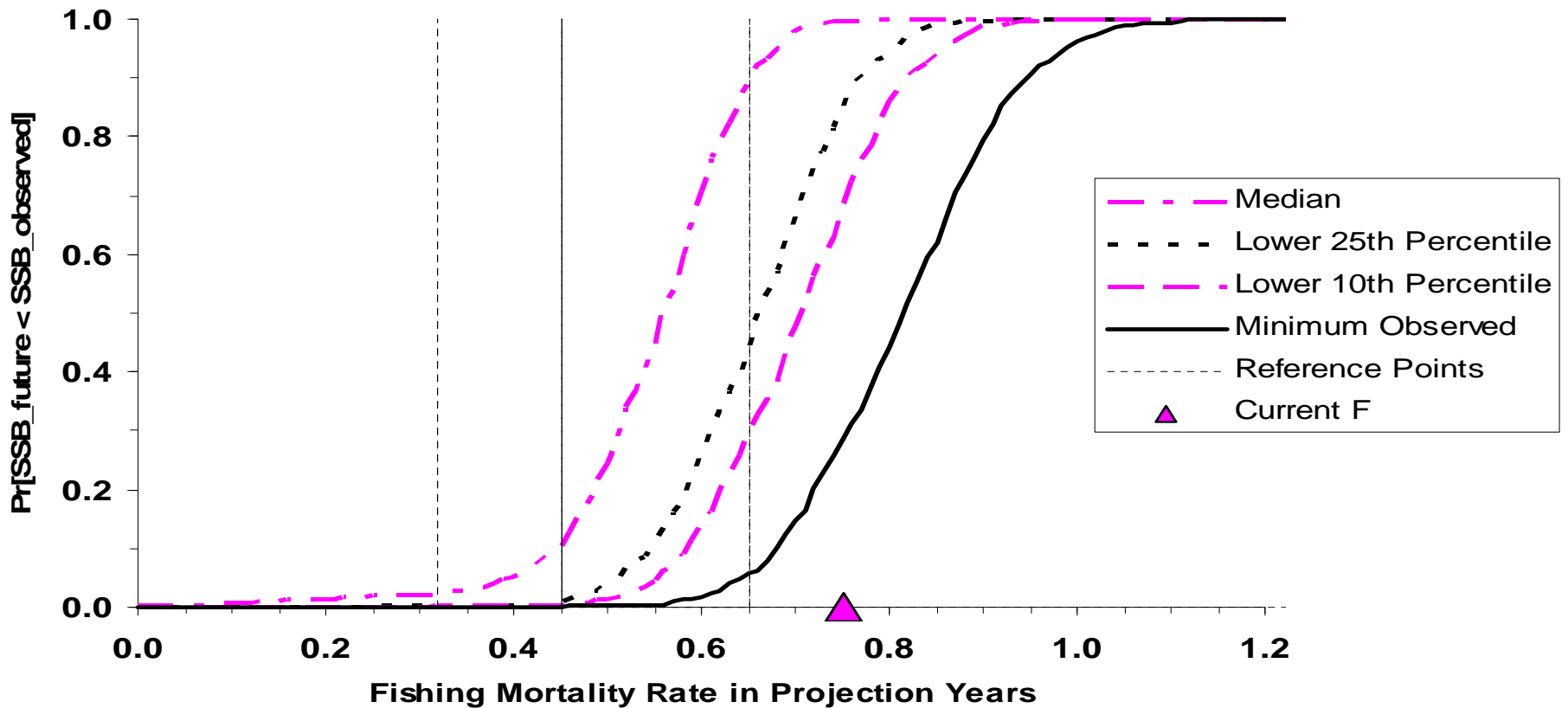
Spawning Stock Biomass with Average Productivity & $F=0.75$
and 90% CI's for Projection Years



Results

Projections and Biological Reference Points

Spawning Stock Biomass with Average Productivity



Results

Projections and Biological Reference Points

*F*s to Maintain SSB Above Threshold

SSB Threshold Desired		Probability Level Desired	
		50%	95%
Minimum Observed SSB	$F_{SSB-Min}$	0.81	0.64
Lower 10th Percentile	$F_{SSB-10\%}$	0.70	0.55
Lower 25th Percentile	$F_{SSB-25\%}$	0.66	0.51
Median	$F_{SSB-50\%}$	0.56	0.39

Conclusions

- ✦ *SSB* in 2006 estimated at about 153,000 mt; 53% above time series average
- ✦ Retrospective analysis showed noticeable trend of over-estimating abundance (say stock size)
- ✦ Over last 15 yr, *R* fluctuated around long-term average of roughly 28 million fish
- ✦ Presently, population is being fished at roughly $F_{17\%}$ (i.e., $F_{2002-2004} = 0.75$) ... similar to 'pessimistic' scenario in 2004 assessment
- ✦ Current *F* (SPR say ...) is high relative to commonly used biological reference points
- ✦ *SSB* is forecasted to decline to an equilibrium level of 92,000 mt by 2015

Conclusions

- ✦ ISC-ALBWG expressed concern about the substantial decline in total catch over the last few years
- ✦ $F_{SSB-MIN}$ analysis indicated that at the 95% probability of success all of the threshold F s would require reductions from current F
- ✦ Finally, at this time, ISC-ALBWG strongly recommended that all countries support 'precautionary' fishing practices

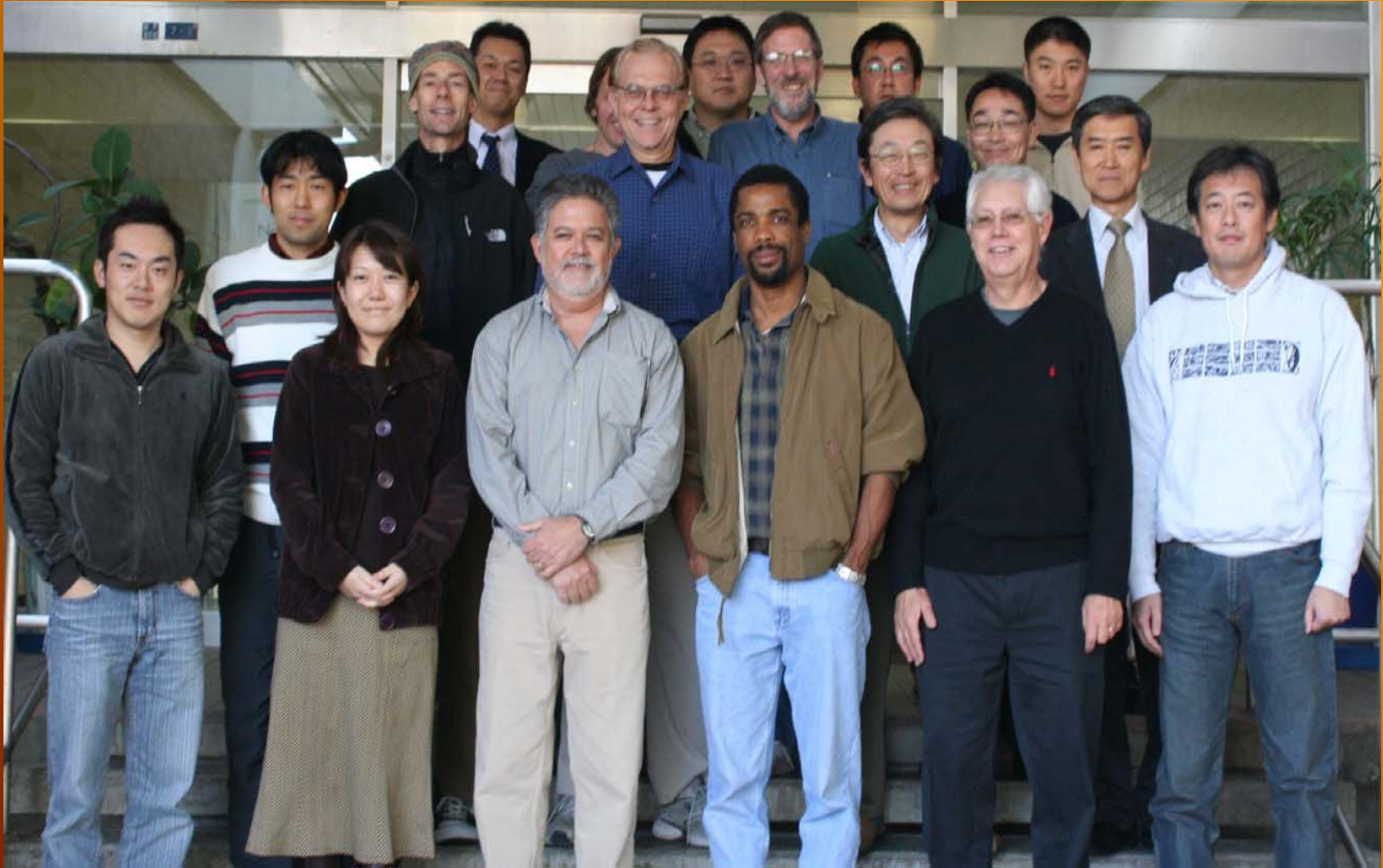
Bottom-line ...

- ✦ Precautionary \equiv limits on current levels of 'fishing effort'

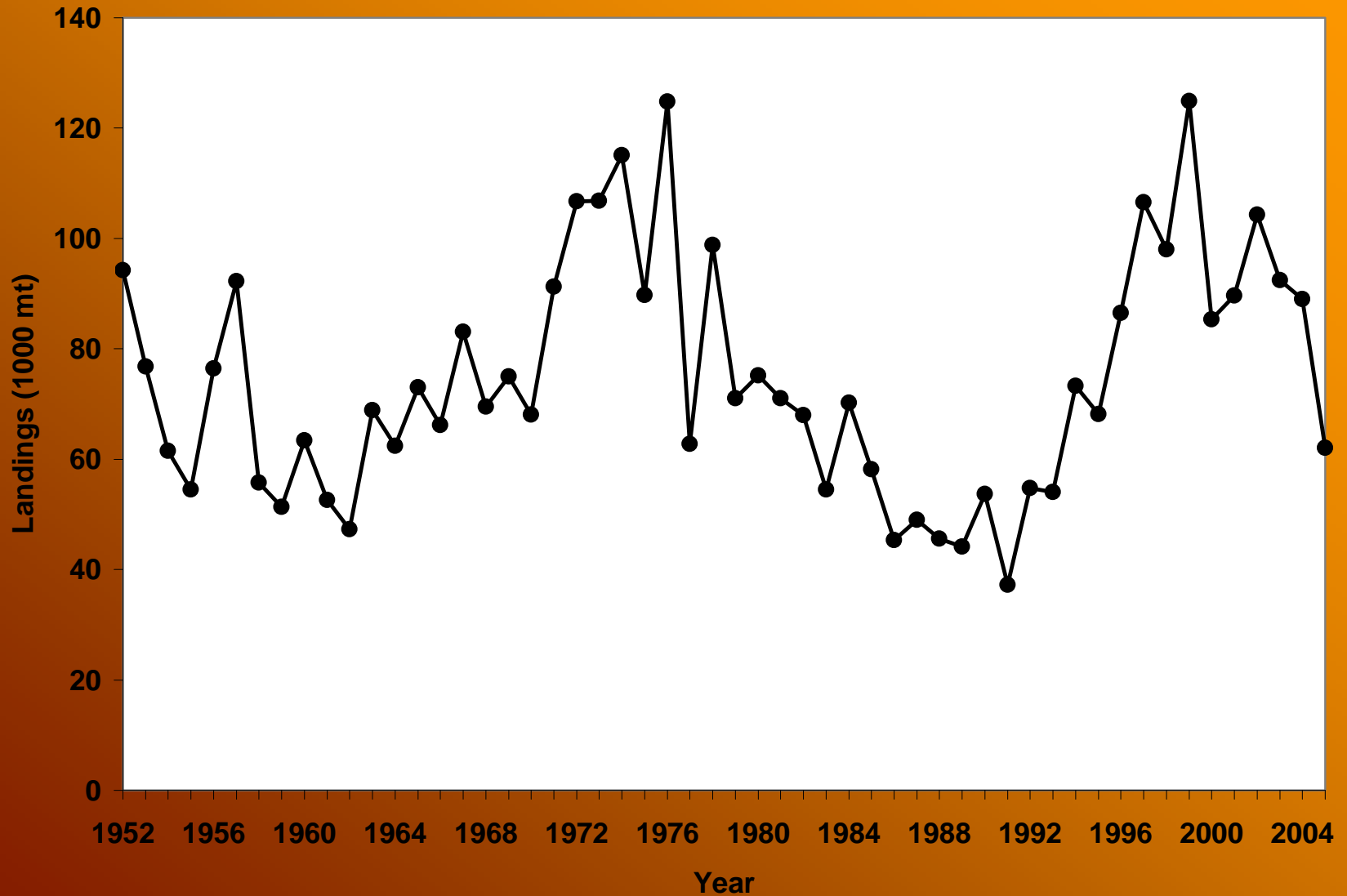
Stuff To Do ...

- ✦ Critical review of CPUE, including data and methods
- ✦ Further development of forward-simulation (SS2 model)
- ✦ Continue efforts formalizing harvest control rule
- ✦ Next meeting (objectives above) is in La Jolla (Feb. 2008)
- ✦ Next assessment is likely late 2008 or early 2009

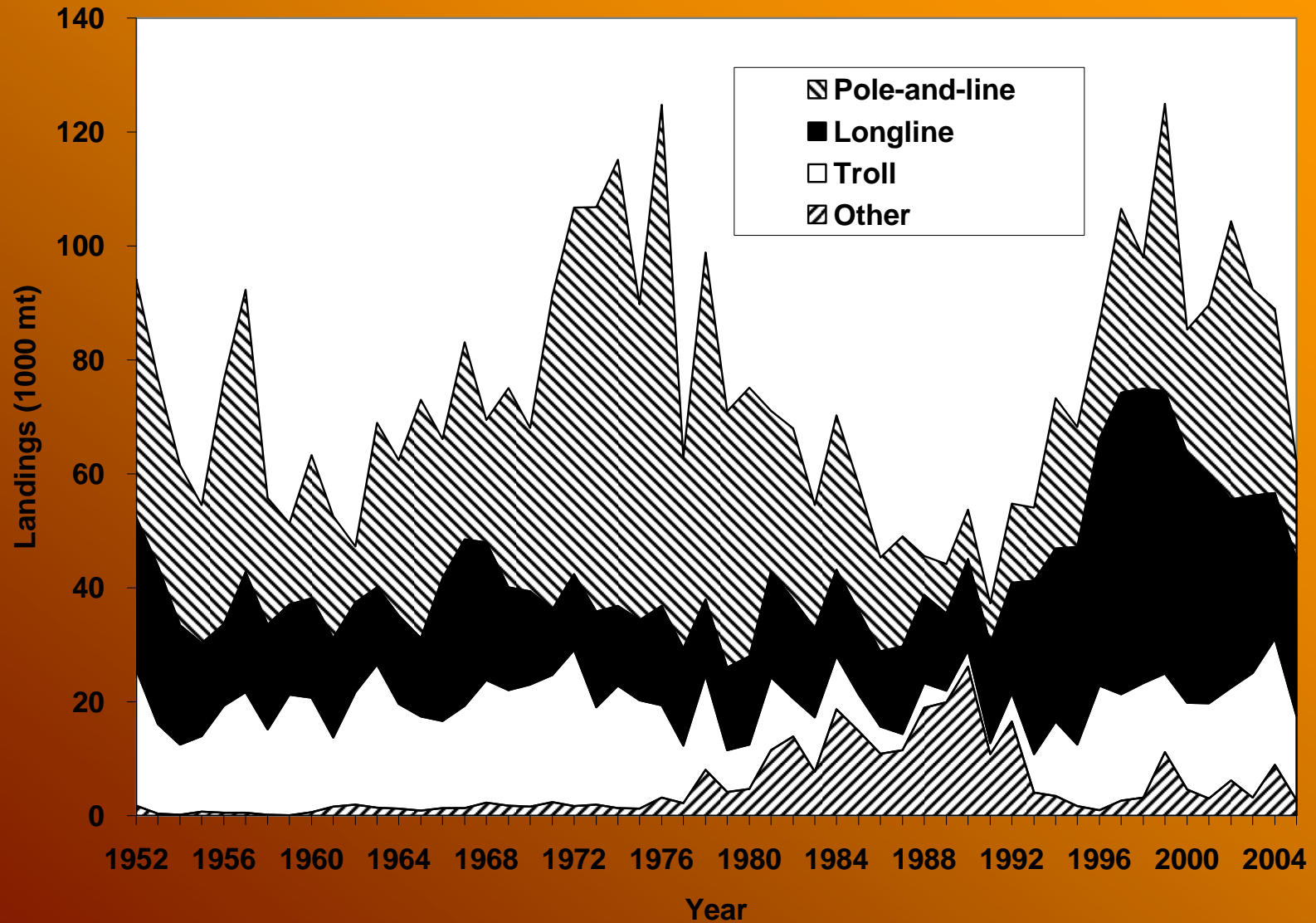
The Folks ...



Landings – all gears and nations (1952-05)



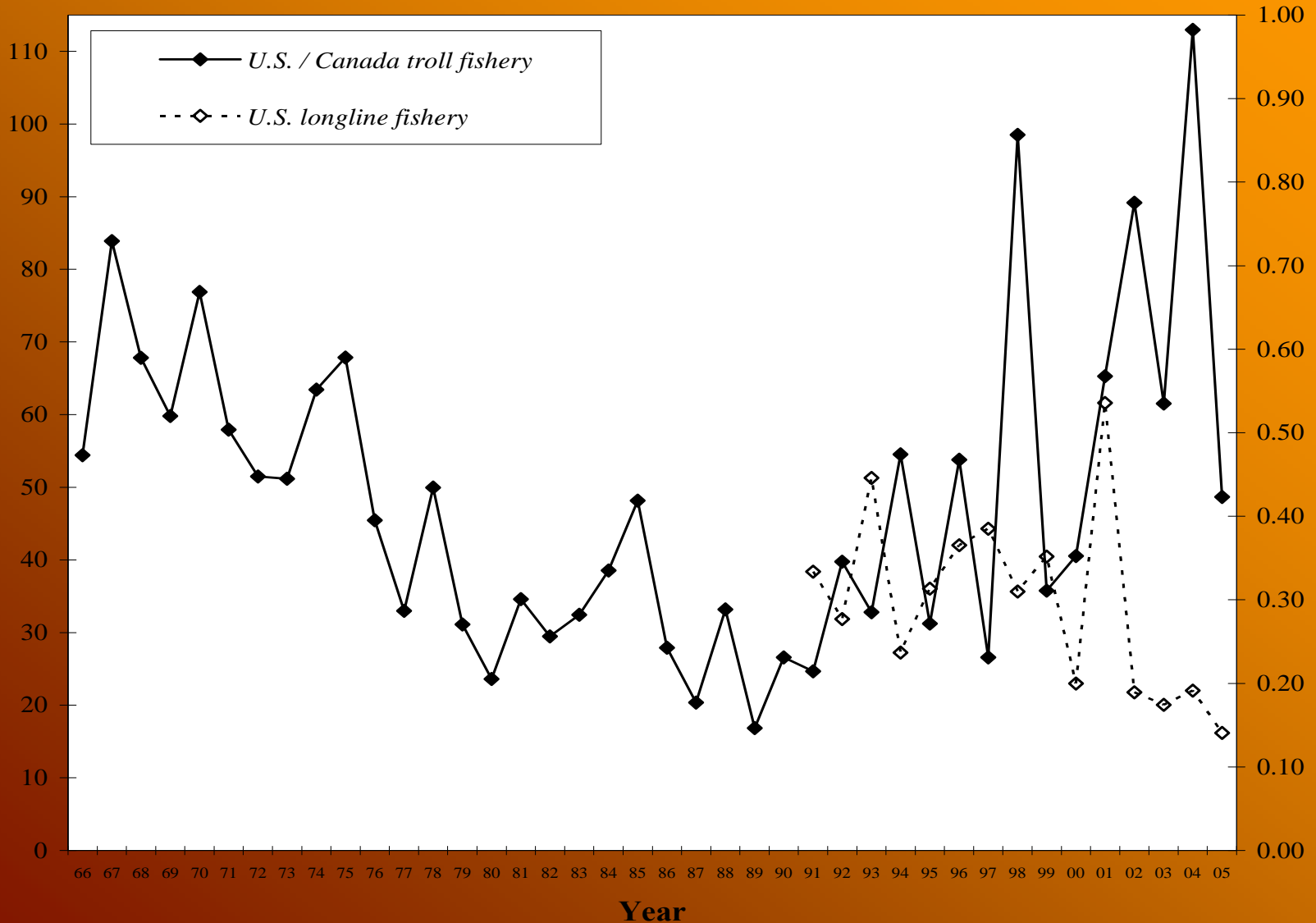
Landings by gear - all nations (1952-05)



U.S. / Canada troll (1966-05) and U.S. longline (1991-05) fisheries

No. fish/day

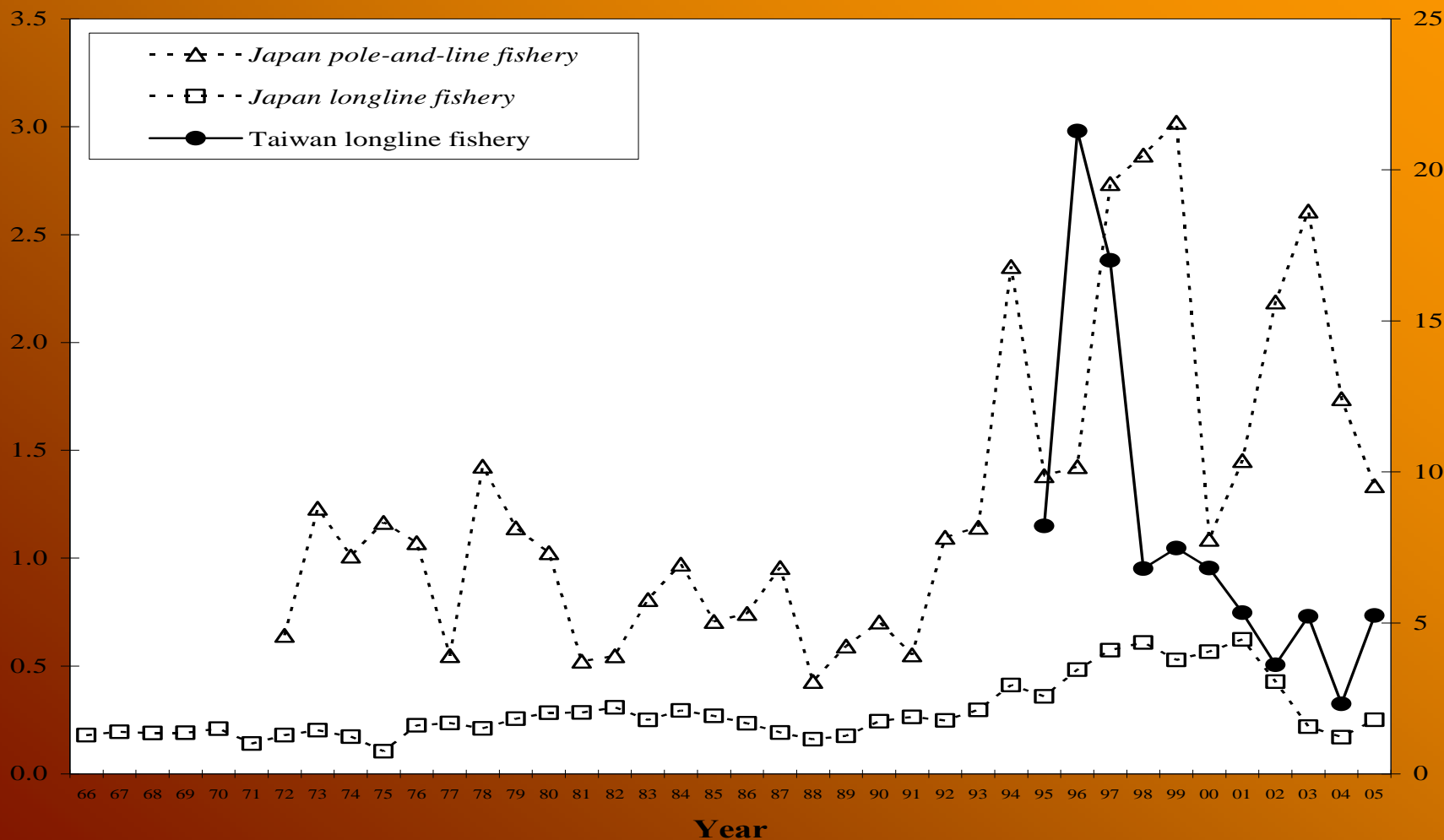
No. fish/1,000
hooks



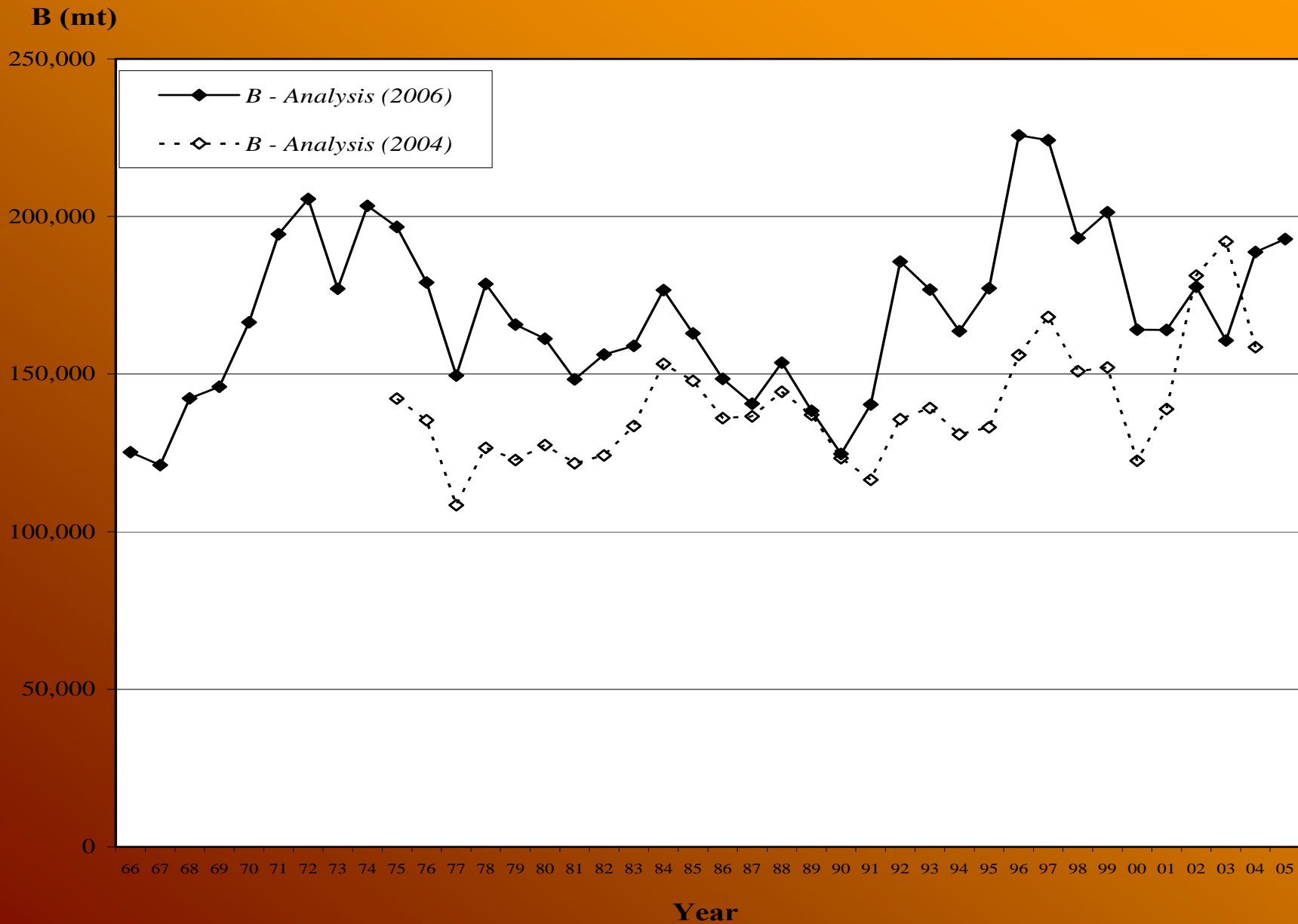
Japan Pole-and-Line (1972-05) Japan Longline (1966-05) and Chinese Taipei Longline (1995-05)

No. fish/pole/day

No. fish/1,000
hooks

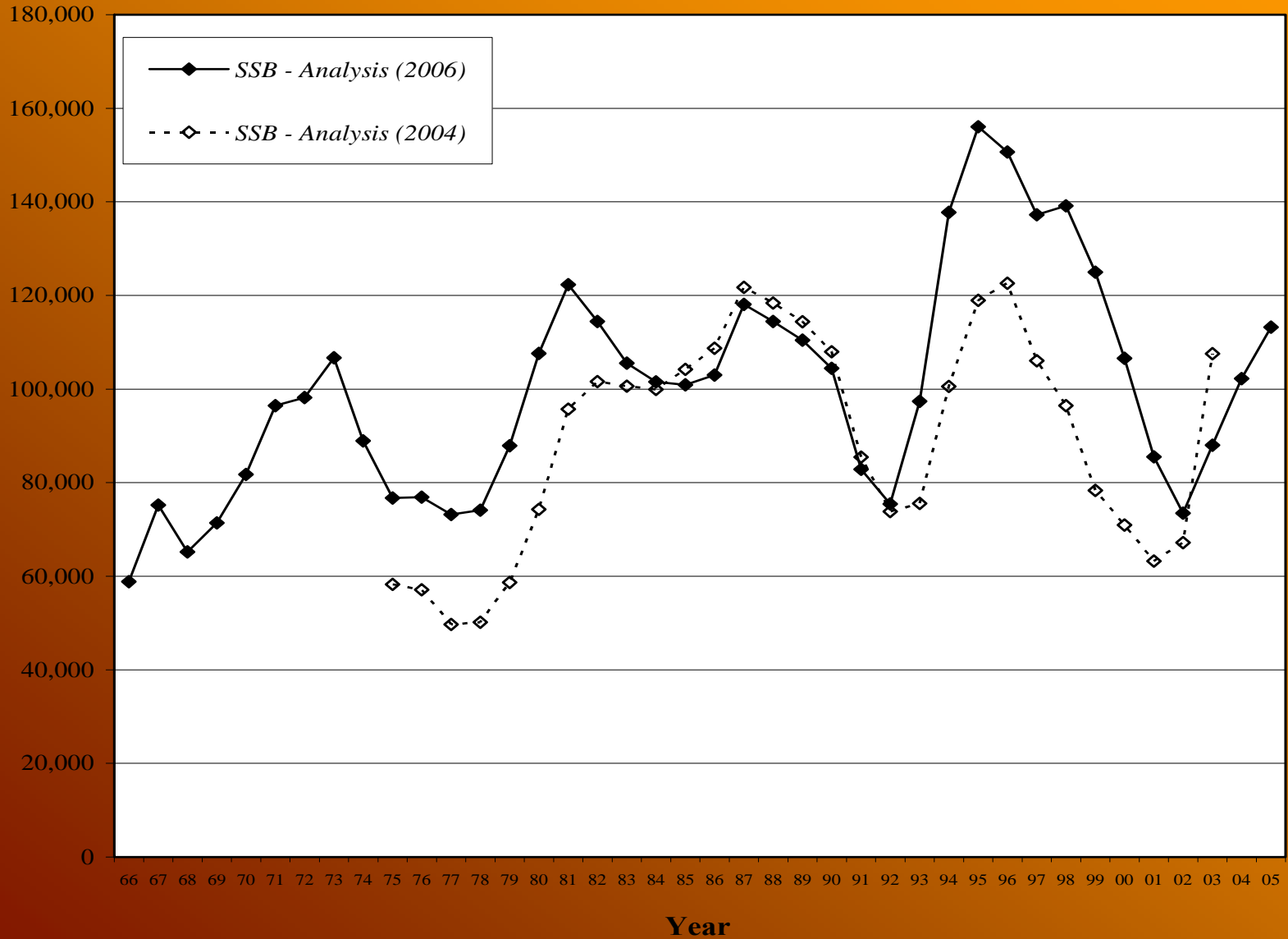


Exploitable Stock Biomass (B)

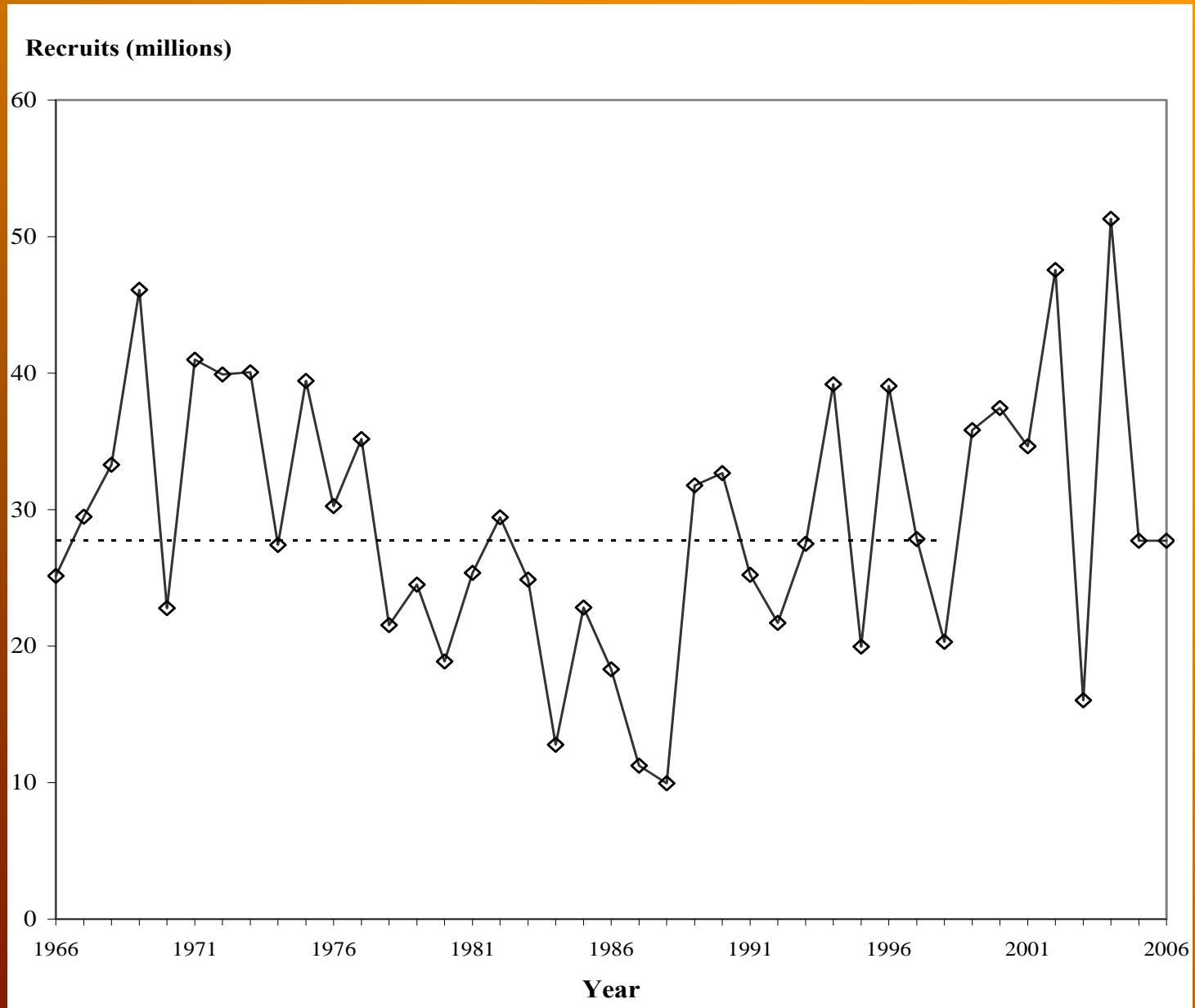


Spawning Stock Biomass (SSB)

SSB (mt)

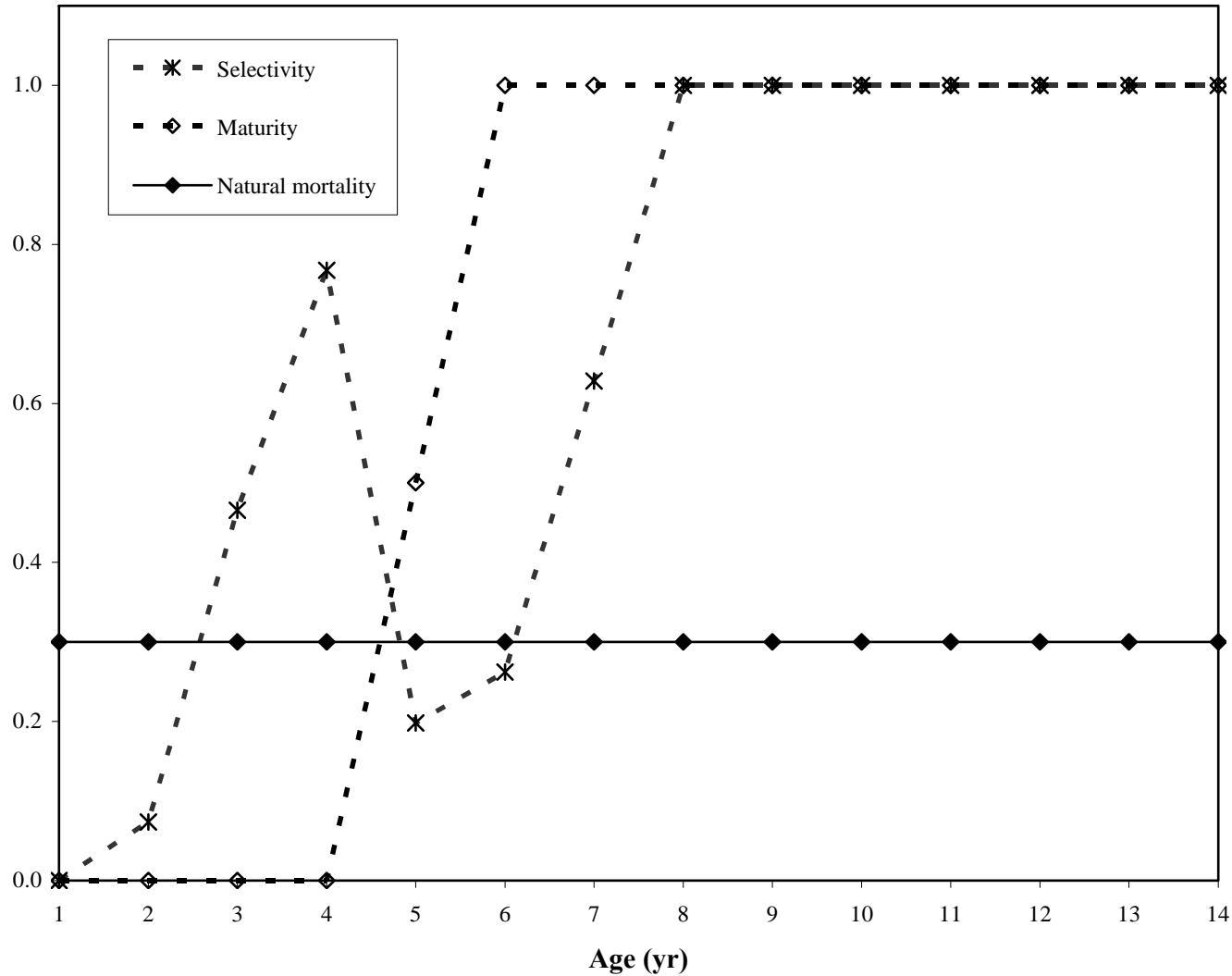


Recruitment (R) – Age-1 Fish (Millions)

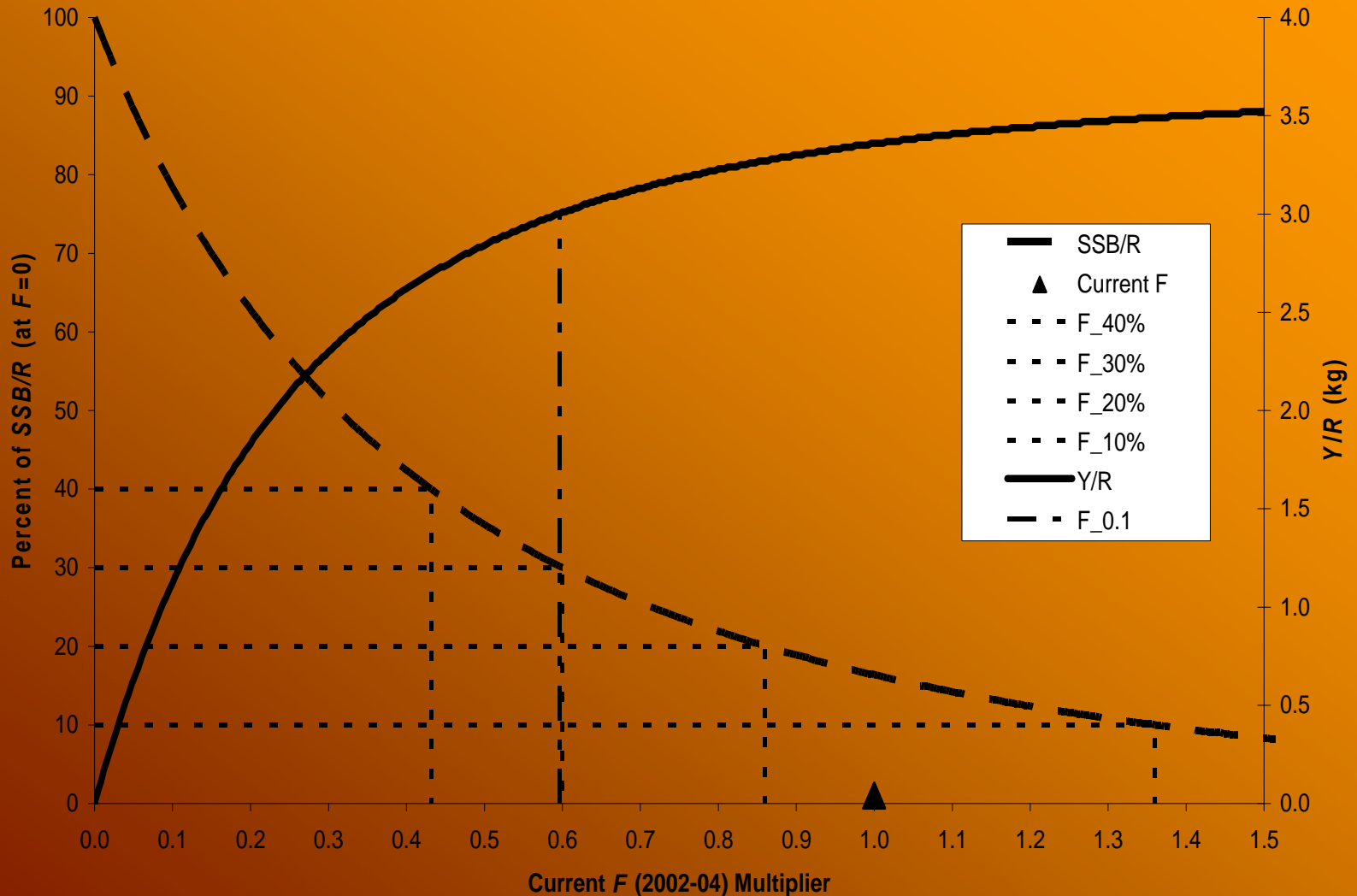


Partial recruitment , Maturity (Ueyangi 1957) and Natural Mortality (M)

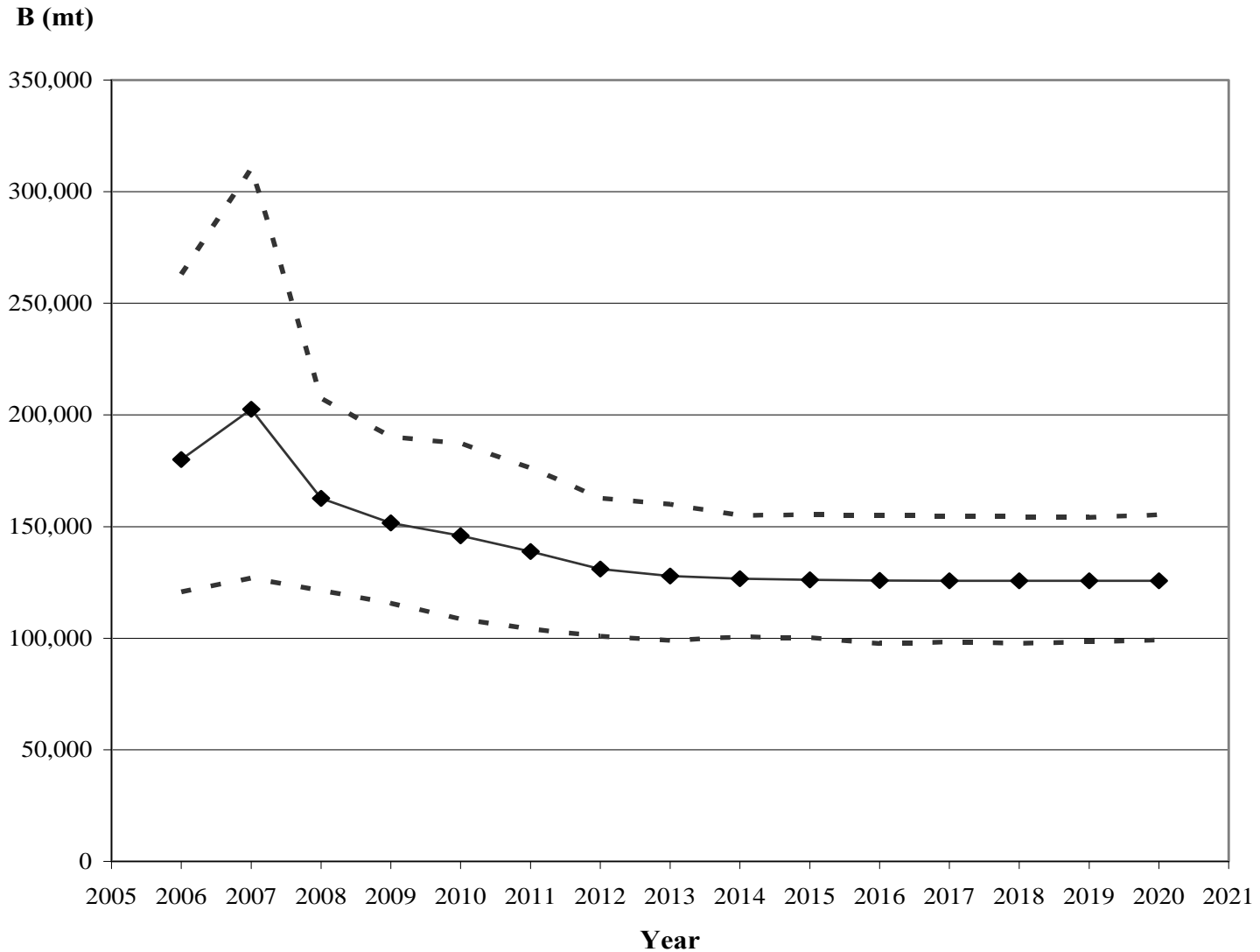
Proportion



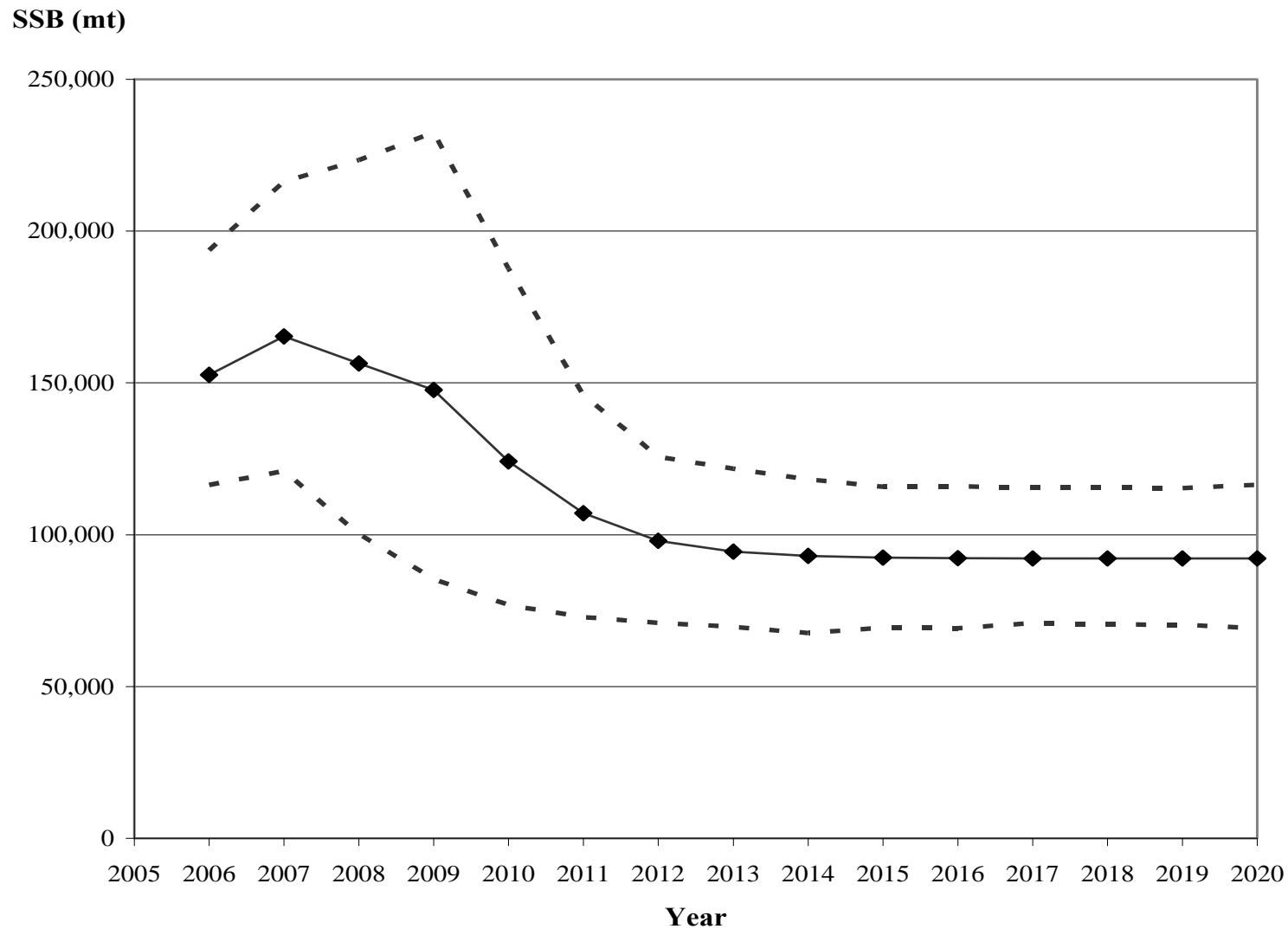
Equilibrium Yield-Per-Recruit (Y/R , in kg) and Percent of SSB/R (relative to $F=0$)



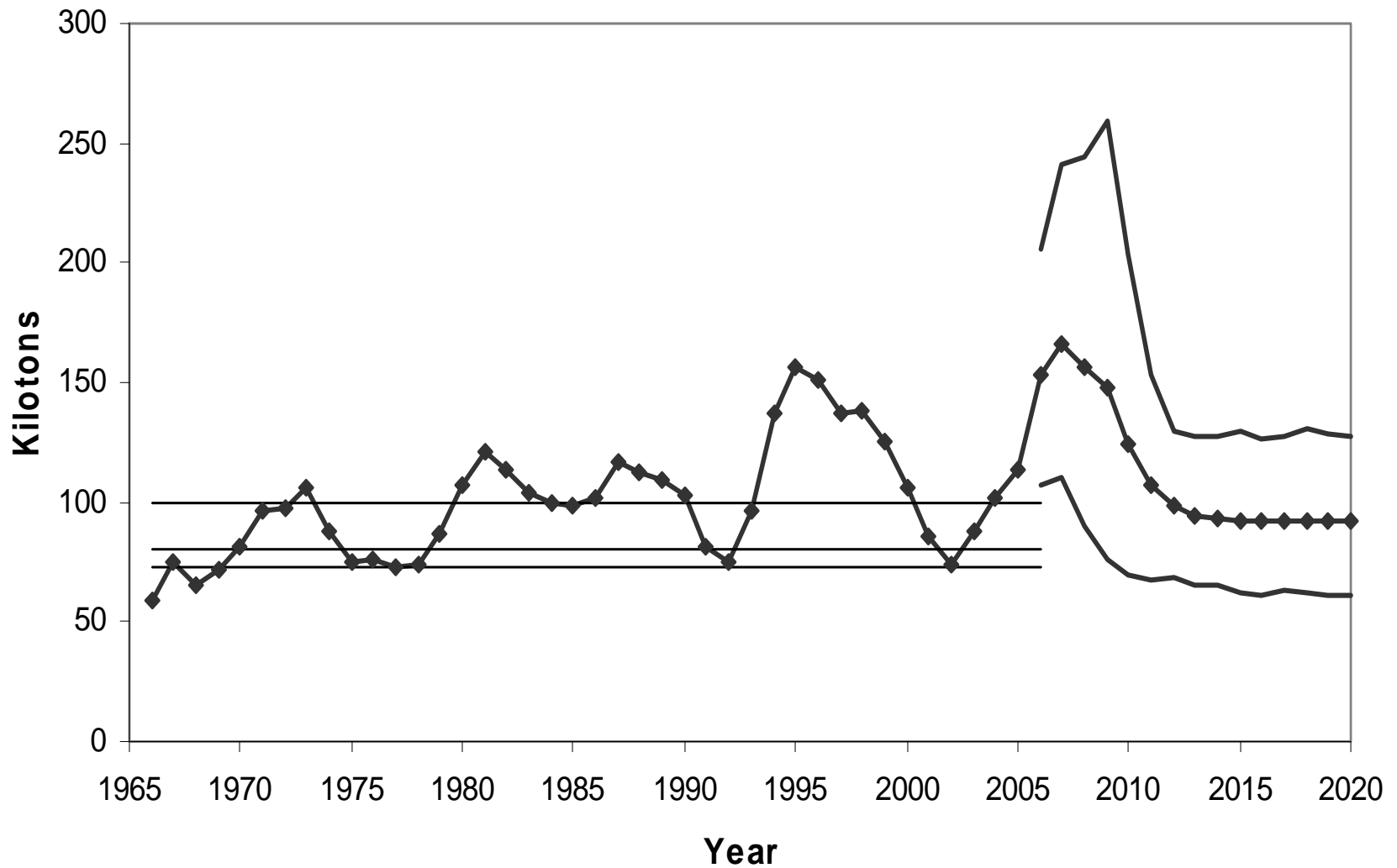
Stochastic projection (2006-20) of 'Exploitable' Biomass (B, mt)



Stochastic Projection (2006-20) of SSB (mt) with 80% CI



SSB with Average Productivity & $F=0.75$ and 90% CI's for Projection Years



Probability Profiles for Four SSB Threshold Levels

Spawning Stock Biomass with Average Productivity

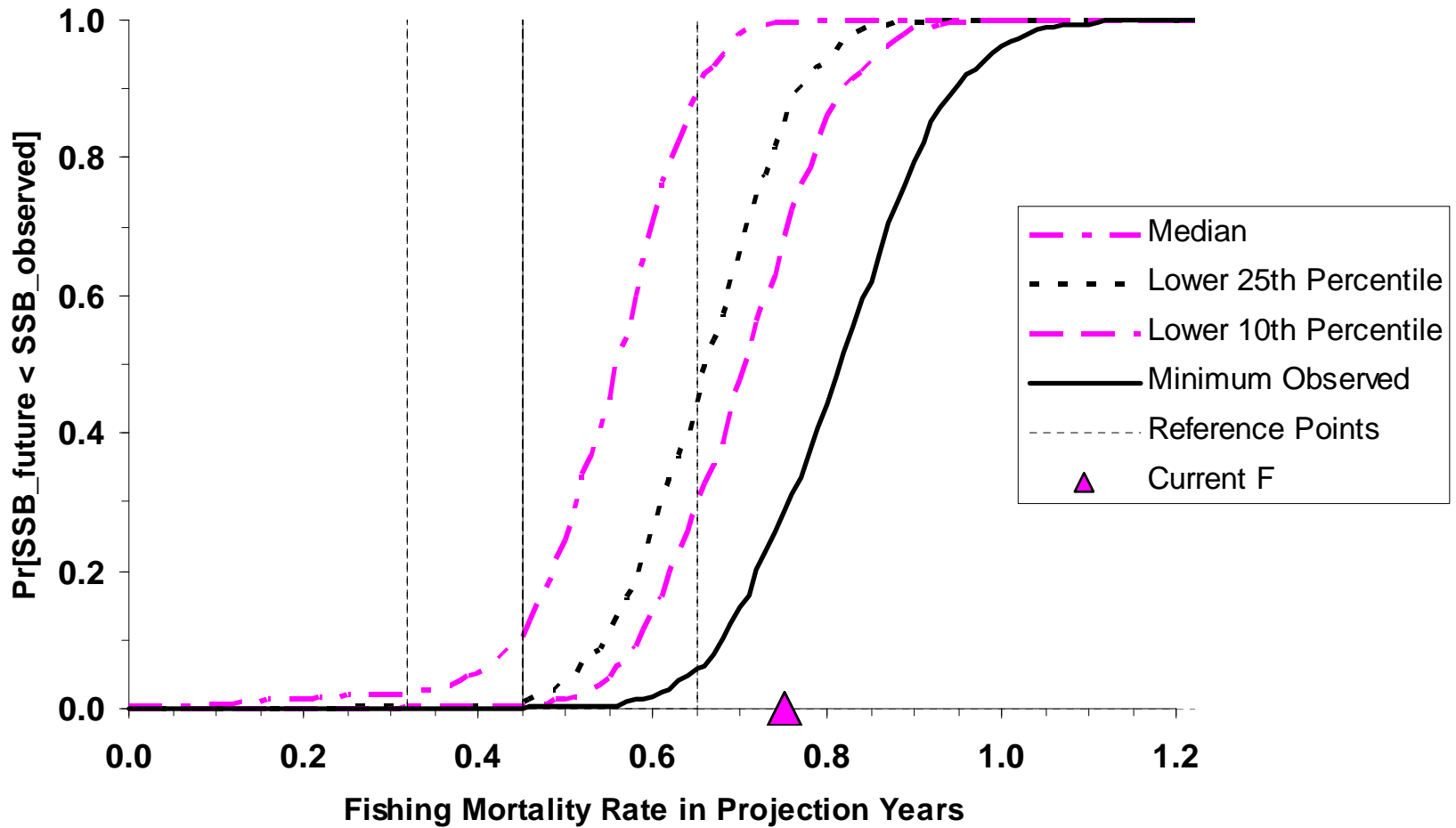


Table 1

YEAR	CANADA	JAPAN						KOREA		MEXICO
	TROLL	GILL NET	LONG LINE	POLE & LINE	PURSE SEINE	TROLL	UNSP. GEAR	GILL NET	LONG LINE	UNSP. GEAR
1952	71		26,687	41,787	154		237			
1953	5		27,777	32,921	38		132			
1954			20,958	28,069	23		38			
1955			16,277	24,236	8		136			
1956	17		14,341	42,810			57			
1957	8		21,053	49,500	83		151			
1958	74		18,432	22,175	8		124			
1959	212		15,802	14,252			67			
1960	5		17,369	25,156			76			
1961	4		17,437	18,639	7		268			0
1962	1		15,764	8,729	53		191			0
1963	5		13,464	26,420	59		218			0
1964	3		15,458	23,858	128		319			0
1965	15		13,701	41,491	11		121			0
1966	44		25,050	22,830	111		585			0
1967	161		28,869	30,481	89		520			
1968	1,028		23,961	16,597	267		1,109			
1969	1,365		18,030	31,912	521		935			0
1970	390		16,283	24,263	317		456			0
1971	1,746		11,524	52,957	902		308			0
1972	3,921	1	13,043	60,569	277		623			100
1973	1,400	39	16,795	68,767	1,353		495			0
1974	1,331	224	13,409	73,564	161		879			1
1975	111	166	10,318	52,152	159		228		2,463	1
1976	278	1,070	15,825	85,336	1,109		272		859	36
1977	53	688	15,696	31,934	669		355		792	0
1978	23	4,029	13,023	59,877	1,115		2,078		228	1
1979	521	2,856	14,215	44,662	125		1,126		0	259
1980	212	2,986	14,689	46,742	329		1,179		6	597
1981	200	10,348	17,922	27,426	252		663		16	459
1982	104	12,511	16,767	29,614	561		440		113	387
1983	225	6,852	15,097	21,098	350		118		233	454
1984	50	8,988	15,060	26,013	3,380		511		516	136
1985	56	11,204	14,351	20,714	1,533		305		576	291
1986	30	7,813	12,928	16,096	1,542		626		726	241
1987	104	6,698	14,702	19,082	1,205		155		817	549
1988	155	9,074	14,731	6,216	1,208		134		1,016	409
1989	140	7,437	13,104	8,629	2,521		393		1,023	150
1990	302	6,064	15,789	8,532	1,995		249		1,016	6
1991	139	3,401	17,046	7,103	2,652		392		852	3
1992	363	2,721	19,049	13,888	4,104		1,527		271	15
1993	494	287	29,966	12,797	2,889		867			32
1994	1,998	263	29,600	26,389	2,026		799			45
1995	1,720	282	29,075	20,981	1,177	856	81			440
1996	3,591	116	32,493	20,272	581	815	117			333
1997	2,433	359	38,951	32,238	1,068	1,585	123			319
1998	4,188	206	35,812	22,926	1,554	1,190	88			288
1999	2,641	289	33,364	50,369	6,872	891	127			107
2000	4,465	67	30,046	21,550	2,408	645	171			414
2001	4,985	117	28,818	29,430	974	416	96			82
2002	5,022	332	23,644	48,454	3,303	787	135			(113)
2003	6,735	126	20,954	36,114	627	922	106			(0)
2004	(7,842)	61	17,547	32,255	7,200	772	65			(0)
2005	(4,810)	(61)	(19,615)	(16,883)	(859)	(772)	(65)			(0)

Table 1 cont.

Table 1. Continued

YEAR	TAIWAN		U.S.							OTHERS		GRAND TOTAL
	GILL NET	LONG LINE ²	POLE & LINE	GILL NET	LONG LINE	PURSE SEINE	SPORT	TROLL	UNSP. GEAR	LONG LINE ³	TROLL	
1952					46		1,373	23,843				94,198
1953					23		171	16,740				76,807
1954					13		147	12,246				61,494
1955					9		577	13,264				54,507
1956					6		482	18,751				76,464
1957					4		304	21,165				92,268
1958					7		48	14,855				55,723
1959					5		0	20,990	0			51,328
1960					4		557	20,100	0			63,403
1961			2,837		5		1,355	12,055	1			52,608
1962			1,085		7		1,681	19,752	1			47,264
1963			2,432		7		1,161	25,140	0			68,906
1964			3,411		4		824	18,388	0			62,393
1965			417		3		731	16,542	0			73,032
1966			1,600		8		588	15,333	1			66,150
1967		330	4,113		12		707	17,814	0			83,096
1968		216	4,906		11		951	20,434	0			69,480
1969		65	2,996		14		358	18,827	0			75,023
1970		34	4,416		9		822	21,032	0			68,022
1971		20	2,071		11		1,175	20,526	0			91,240
1972		187	3,750		8		637	23,600	0			106,717
1973		--	2,236		14		84	15,653	0			106,836
1974		486	4,777		9		94	20,178	0			115,113
1975		1,240	3,243		33		640	18,932	10			89,696
1976		686	2,700		23		713	15,905	4			124,816
1977		572	1,497		37		537	9,969	0			62,799
1978		6	950		54		810	16,613	15			98,822
1979		81	303		--		74	6,781	0			71,004
1980	--	249	382		--		168	7,556	0			75,126
1981	--	143	748		25		195	12,637	0			71,042
1982	--	38	425		105		257	6,609	21			67,960
1983	--	8	607		6		87	9,359	0			54,527
1984	--	--	1,030		2	3,728	1,427	9,304	0			70,258
1985	--	--	1,498		0		1,176	6,415	0			58,170
1986	--	--	432	3			196	4,708	0			45,344
1987	2,514	--	158	5	150		74	2,766	0			48,986
1988	7,389	--	598	15	308		64	4,212	10			45,554
1989	8,350	40	54	4	249		160	1,860	23			44,140
1990	16,701	4	115	29	177	71	24	2,603	4			53,683
1991	3,398	12	0	17	313	0	6	1,845	71			37,253
1992	7,866	--	0	0	337	0	2	4,572	72			54,796
1993		5	0	0	440		25	6,254	0			54,067
1994		83	0	38	546		106	10,978	213		158	73,248
1995		4,280	80	52	883		102	8,045	1		137	68,197
1996		7,596	24	83	1,187	11	88	16,938	0	1,735	505	86,506
1997		9,119	73	60	1,652	2	1,018	14,252	1	2,824	404	106,534
1998		8,617	79	80	1,120	33	1,208	14,410	2	5,871	286	97,966
1999		8,186	60	149	1,540	48	3,621	10,060	1	6,307	261	124,916
2000		8,842	69	55	940	4	1,798	9,645	3	3,654	490	85,344
2001		8,684	139	94	1,295	51	1,635	11,210	0	1,471	127	89,648
2002		7,965	381	30	525	4	2,357	10,387	0	700	(127)	(104,295)
2003		(7,166)	59	16	524	44	2,214	14,102	0	(2,400)	(127)	(92,409)
2004		(4,988)	(126)	(12)	(560)	(1)	(1,506)	(13,346)	(0)	(2,400)	(127)	(88,981)
2005		(4,692)	(66)	(20)	(277)	(2)	(1,719)	(9,122)	(0)	(2,400)	(127)	(62,011)

Table 2

YEAR	AGE (yr)									TOTAL
	1	2	3	4	5	6	7	8	= 9	
1966	0	129	2,022	1,118	2,412	261	145	52	41	6,180
1967	0	210	2,293	1,552	2,820	579	171	97	72	7,794
1968	0	92	3,268	1,422	1,118	763	254	97	39	7,053
1969	1	2,046	2,584	1,232	2,493	197	191	194	53	8,990
1970	0	282	3,390	2,220	1,321	410	101	71	61	7,856
1971	0	208	4,634	2,424	2,831	388	175	70	81	10,810
1972	0	4,030	3,514	4,646	2,348	270	118	92	60	15,078
1973	1	2,583	3,619	1,531	4,030	743	141	90	74	12,812
1974	0	1,128	4,483	5,653	1,538	754	153	57	96	13,863
1975	0	828	5,222	2,912	1,907	264	111	78	259	11,581
1976	0	2,325	4,937	5,767	2,766	285	165	106	186	16,538
1977	0	741	2,919	1,955	1,106	426	132	91	160	7,531
1978	2	5,931	2,125	4,729	1,018	387	185	45	83	14,505
1979	0	580	1,215	3,623	1,257	265	190	101	68	7,300
1980	0	2,518	2,830	3,160	801	311	110	87	97	9,916
1981	4	898	1,509	2,854	1,095	450	270	106	115	7,301
1982	78	599	1,949	3,408	435	255	200	213	134	7,272
1983	2	1,182	2,552	2,306	232	186	196	146	141	6,945
1984	5	1,111	4,571	3,031	241	177	126	131	156	9,550
1985	2	318	1,235	2,776	641	118	166	100	325	5,681
1986	0	794	906	2,461	204	128	127	90	131	4,840
1987	1	265	2,155	1,296	474	314	176	102	169	4,953
1988	4	133	1,529	1,156	270	606	223	161	181	4,264
1989	106	377	316	1,335	1,012	276	246	133	158	3,959
1990	109	317	239	1,151	1,606	641	113	213	247	4,635
1991	78	678	1,747	335	339	263	155	119	271	3,984
1992	1	332	2,350	1,664	662	360	150	151	156	5,826
1993	0	485	1,090	1,971	793	202	201	116	293	5,151
1994	28	669	1,575	2,355	1,077	654	206	97	136	6,798
1995	2	496	1,310	3,152	294	310	564	116	119	6,362
1996	8	494	3,938	2,294	603	396	554	477	105	8,869
1997	0	2,453	1,431	4,451	817	124	476	620	391	10,764
1998	0	1,105	4,036	1,568	1,880	302	213	379	282	9,766
1999	77	816	3,761	5,797	757	478	477	185	308	12,656
2000	0	1,231	1,852	2,739	923	415	450	435	247	8,292
2001	4	1,470	4,370	1,396	1,153	410	451	277	338	9,869
2002	0	1,447	7,396	3,141	439	226	381	209	222	13,461
2003	0	3,054	3,619	3,008	709	306	250	181	194	11,321
2004	30	210	4,411	4,363	282	452	332	130	44	10,253
2005	1	2,382	1,547	2,318	305	171	437	189	69	7,418
TOTAL	543	46,948	110,447	106,273	47,010	14,522	9,484	6,404	6,365	347,996

Table 3

YEAR	AGE (yr)								
	1	2	3	4	5	6	7	8	=9
1966	25,148	20,076	9,549	8,963	5,558	1,035	424	166	131
1967	29,475	18,630	14,762	5,352	5,685	2,083	545	191	142
1968	33,293	21,836	13,622	8,980	2,647	1,842	1,052	259	105
1969	46,100	24,664	16,098	7,312	5,439	1,018	720	563	154
1970	22,784	34,151	16,522	9,721	4,365	1,930	586	371	322
1971	40,983	16,879	25,058	9,353	5,312	2,113	1,081	348	401
1972	39,890	30,361	12,325	14,614	4,869	1,562	1,235	651	427
1973	40,054	29,551	19,050	6,147	6,887	1,632	927	814	669
1974	27,404	29,672	19,683	11,028	3,253	1,735	583	566	958
1975	39,421	20,302	21,015	10,766	3,424	1,116	650	302	999
1976	30,252	29,204	14,331	11,128	5,502	941	602	387	676
1977	35,167	22,411	19,646	6,435	3,405	1,752	455	306	539
1978	21,530	26,052	15,968	12,063	3,108	1,585	936	224	413
1979	24,512	15,948	14,252	10,014	4,940	1,440	845	536	363
1980	18,877	18,159	11,318	9,519	4,353	2,591	840	464	522
1981	25,360	13,984	11,302	5,978	4,374	2,542	1,654	528	574
1982	29,433	18,784	9,591	7,084	2,028	2,310	1,499	995	628
1983	24,877	21,738	13,402	5,445	2,382	1,132	1,493	939	907
1984	12,774	18,427	15,092	7,753	2,088	1,566	680	938	1,123
1985	22,816	9,460	12,700	7,301	3,182	1,341	1,009	396	1,282
1986	18,306	16,901	6,735	8,352	3,062	1,812	892	606	881
1987	11,247	13,562	11,841	4,216	4,099	2,094	1,233	553	913
1988	9,944	8,331	9,819	6,935	2,024	2,631	1,283	763	855
1989	31,762	7,364	6,058	5,969	4,151	1,269	1,433	760	907
1990	32,674	23,439	5,132	4,218	3,286	2,215	705	852	987
1991	25,211	24,112	17,092	3,598	2,146	1,084	1,097	426	971
1992	21,691	18,610	17,282	11,169	2,378	1,300	580	680	704
1993	27,488	16,068	13,502	10,796	6,854	1,200	657	302	765
1994	39,176	20,363	11,488	9,071	6,317	4,400	717	317	444
1995	19,968	28,999	14,513	7,165	4,718	3,761	2,701	356	366
1996	39,051	14,791	21,057	9,631	2,652	3,244	2,521	1,521	335
1997	27,849	28,923	10,535	12,243	5,184	1,451	2,065	1,396	881
1998	20,315	20,631	19,329	6,582	5,303	3,143	969	1,124	835
1999	35,829	15,049	14,338	10,882	3,542	2,338	2,070	536	892
2000	37,451	26,476	10,450	7,425	3,202	1,979	1,325	1,127	640
2001	34,645	27,744	18,559	6,163	3,183	1,589	1,113	601	733
2002	47,549	25,662	19,295	10,031	3,378	1,383	828	444	470
2003	16,034	35,225	17,772	8,042	4,767	2,127	831	293	314
2004	51,304	11,878	23,484	10,083	3,414	2,927	1,315	404	136
2005	27,722	37,981	8,620	13,638	3,791	2,288	1,782	692	252
2006	27,722	20,517	26,099	5,067	8,126	2,547	1,549	949	481

Table 4

YEAR	AGE (yr)								
	1	2	3	4	5	6	7	8	=9
1966	0.000	0.007	0.279	0.155	0.681	0.341	0.496	0.439	0.439
1967	0.000	0.013	0.197	0.404	0.827	0.383	0.446	0.859	0.859
1968	0.000	0.005	0.322	0.201	0.656	0.639	0.324	0.561	0.561
1969	0.000	0.101	0.204	0.216	0.736	0.252	0.362	0.499	0.499
1970	0.000	0.010	0.269	0.304	0.426	0.280	0.222	0.247	0.247
1971	0.000	0.014	0.239	0.353	0.924	0.237	0.207	0.263	0.263
1972	0.000	0.166	0.396	0.452	0.793	0.222	0.117	0.177	0.177
1973	0.000	0.106	0.247	0.337	1.079	0.729	0.192	0.137	0.137
1974	0.000	0.045	0.303	0.870	0.770	0.682	0.359	0.123	0.123
1975	0.000	0.048	0.336	0.371	0.992	0.317	0.218	0.354	0.354
1976	0.000	0.096	0.501	0.884	0.844	0.427	0.376	0.379	0.379
1977	0.000	0.039	0.188	0.428	0.465	0.327	0.406	0.415	0.415
1978	0.000	0.303	0.167	0.593	0.470	0.329	0.257	0.263	0.263
1979	0.000	0.043	0.104	0.533	0.345	0.238	0.299	0.244	0.244
1980	0.000	0.174	0.338	0.478	0.238	0.149	0.164	0.242	0.242
1981	0.000	0.077	0.167	0.781	0.339	0.228	0.208	0.262	0.262
1982	0.003	0.038	0.266	0.790	0.283	0.136	0.167	0.282	0.282
1983	0.000	0.065	0.247	0.659	0.119	0.210	0.164	0.197	0.197
1984	0.000	0.072	0.426	0.590	0.143	0.140	0.240	0.175	0.175
1985	0.000	0.040	0.119	0.569	0.263	0.107	0.209	0.344	0.344
1986	0.000	0.056	0.168	0.412	0.080	0.085	0.179	0.188	0.188
1987	0.000	0.023	0.235	0.434	0.143	0.189	0.180	0.239	0.239
1988	0.000	0.019	0.198	0.213	0.167	0.307	0.224	0.279	0.279
1989	0.004	0.061	0.062	0.297	0.328	0.287	0.221	0.224	0.224
1990	0.004	0.016	0.055	0.375	0.809	0.403	0.204	0.338	0.338
1991	0.004	0.033	0.125	0.114	0.201	0.326	0.178	0.385	0.385
1992	0.000	0.021	0.170	0.188	0.384	0.382	0.351	0.294	0.294
1993	0.000	0.036	0.098	0.236	0.143	0.215	0.430	0.576	0.576
1994	0.001	0.039	0.172	0.354	0.219	0.188	0.401	0.431	0.431
1995	0.000	0.020	0.110	0.694	0.075	0.100	0.274	0.467	0.467
1996	0.000	0.039	0.242	0.319	0.303	0.152	0.291	0.445	0.445
1997	0.000	0.103	0.170	0.537	0.200	0.104	0.308	0.703	0.703
1998	0.000	0.064	0.274	0.320	0.519	0.118	0.292	0.487	0.487
1999	0.003	0.065	0.358	0.923	0.282	0.268	0.308	0.503	0.503
2000	0.000	0.055	0.228	0.547	0.401	0.276	0.491	0.580	0.580
2001	0.000	0.063	0.315	0.301	0.534	0.351	0.619	0.743	0.743
2002	0.000	0.067	0.575	0.444	0.162	0.209	0.739	0.768	0.768
2003	0.000	0.105	0.267	0.557	0.188	0.181	0.422	1.192	1.192
2004	0.001	0.021	0.243	0.678	0.100	0.196	0.342	0.461	0.461
2005	0.001	0.075	0.231	0.218	0.098	0.090	0.331	0.375	0.375

Table 5a

Candidate Target	Target F	Ratio of Current F	MSY Proxy	SSB_{MSY} Proxy
Reference Points	(yr^{-1})	to Target F	(1,000 mt)	(1,000 mt)
$F_{40\%}$	0.32	2.31	75	226
$F_{35\%}$	0.38	1.97	79	198
$F_{0.1}$	0.45	1.68	83	171
$F_{30\%}$	0.45	1.67	83	169
Candidate Limit	Limit F	Ratio of Current F	Equilibrium Catch	Equilibrium SSB
Reference Points	(yr^{-1})	to Limit F	(1,000 mt)	(1,000 mt)
$F_{20\%}$	0.65	1.16	91	113
F_{Max}	2.07	0.36	100	10
$F_{SSB-Min}$	0.81	0.93	94	83
$F_{SSB-10\%}$	0.70	1.07	92	102
$F_{SSB-25\%}$	0.66	1.14	91	110

Table 5b

BRPs	2006	2004	2004	2004	2004
Productivity in recent years	Average	Low	High	Low	High
F_{cur} Scenario	0.75	Low 0.43	Low 0.43	High 0.68	High 0.68
$F_{cur}/F_{40\%}$	2.31	1.43	1.43	2.27	2.27
$F_{cur}/F_{35\%}$	1.97	1.23	1.23	1.94	1.94
$F_{cur}/F_{0.1}$	1.68	1.16	1.16	1.84	1.84
$F_{cur}/F_{30\%}$	1.67	1.02	1.02	1.62	1.62
$F_{cur}/F_{20\%}$	1.16	0.70	0.70	1.11	1.11
F_{cur}/F_{max}	0.36	0.40	0.40	0.64	0.64
$F_{cur}/F_{SSB-Min}$	0.93	0.48	0.41	0.76	0.65
$F_{cur}/F_{SSB-10\%}$	1.07	0.52	0.44	0.83	0.69
$F_{cur}/F_{SSB-25\%}$	1.14	0.60	0.50	0.94	0.79
$F_{cur}/F_{SSB-50\%}$	1.34	0.80	0.64	1.26	1.01

Table 6a

YEAR	AGE (yr)								
	1	2	3	4	5	6	7	8	9+
1966	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.73
1967	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.73
1968	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.73
1969	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.73
1970	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.73
1971	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.73
1972	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.73
1973	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.73
1974	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.13
1975	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.13
1976	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.13
1977	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.13
1978	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.13
1979	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.46
1980	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.46
1981	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.46
1982	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.46
1983	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.46
1984	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.52
1985	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.52
1986	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.52
1987	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.52
1988	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	30.52
1989	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.67
1990	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.67
1991	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.67
1992	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.67
1993	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	29.67
1994	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.86
1995	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.86
1996	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.86
1997	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.86
1998	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.86
1999	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.10
2000	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.10
2001	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.10
2002	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.10
2003	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.10
2004	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.03
2005	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.03
2006	1.26	3.23	5.93	9.13	12.62	16.20	19.75	23.17	28.03

Table 6b

YEAR	AGE (yr)								
	1	2	3	4	5	6	7	8	9+
1966	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.24
1967	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.24
1968	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.24
1969	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.24
1970	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.24
1971	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.24
1972	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.24
1973	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.24
1974	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.61
1975	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.61
1976	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.61
1977	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.61
1978	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.61
1979	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.91
1980	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.91
1981	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.91
1982	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.91
1983	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.91
1984	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.97
1985	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.97
1986	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.97
1987	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.97
1988	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.97
1989	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.19
1990	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.19
1991	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.19
1992	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.19
1993	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	31.19
1994	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	30.44
1995	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	30.44
1996	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	30.44
1997	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	30.44
1998	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	30.44
1999	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	29.74
2000	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	29.74
2001	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	29.74
2002	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	29.74
2003	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	29.74
2004	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	29.68
2005	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	29.68
2006	2.26	4.76	7.86	11.30	14.88	18.44	21.88	25.13	29.68

Table 6c

Period	Mean F on Age group 9+	Age group 9+ equilibrium demographics					
		Biomass (January 1)			Spawning stock biomass (May 1)		
		Mean age (yr)	Mean length (cm)	Mean weight (kg)	Mean age (yr)	Mean length (cm)	Mean weight (kg)
2002-2004	0.7501	9.54	115.60	28.03	9.87	117.10	29.68
1999-2003	0.7236	9.56	115.70	28.10	9.89	117.20	29.74
1994-1998	0.4981	9.82	116.87	28.86	10.15	118.30	30.44
1989-1993	0.3457	10.10	118.09	29.67	10.44	119.47	31.19
1984-1988	0.2374	10.41	119.35	30.52	10.74	120.66	31.97
1979-1983	0.2437	10.38	119.26	30.46	10.72	120.58	31.91
1974-1978	0.2826	10.26	118.77	30.13	10.60	120.11	31.61
1966-1973	0.3370	10.12	118.18	29.73	10.46	119.55	31.24

Table 7

Probability Level Desired

SSB Threshold Desired

50%

95%

Minimum Observed SSB

$F_{SSB-Min}$

0.81

0.64

Lower 10th Percentile

$F_{SSB-10\%}$

0.70

0.55

Lower 25th Percentile

$F_{SSB-25\%}$

0.66

0.51

Median

$F_{SSB-50\%}$

0.56

0.39