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Review Table of Vital Rates and Life History Parameters for Striped Marlin, Swordfish, and Blue Marlin in the North Pacific Ocean [1]

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REVIEW TABLE OF VITAL RATES AND LIFE HISTORY PARAMETERS FOR STRIPED MARLIN, SWORDFISH, AND BLUE MARLIN IN THE NORTH PACIFIC OCEAN

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The intent of this working paper was to compile available data on vital rates and life history parameters and present it in a tabulated format for stock assessment scientists. As this information occurs in a variety of published reports, in both peer-reviewed journal articles and gray literature, compiling this information into an accessible format is important. Furthermore, we hope this format will also allow researchers to more easily determine where gaps exist in our knowledge of important vital rates and life history parameters. Information provided in each table has been footnoted and the literature source cited.

Since the authors are based in the central North Pacific region, the information provided on billfish vital rates and life history parameters is more complete for this region than the western and eastern North Pacific regions. We have undoubtedly overlooked information from the latter two regions and caution the reader that this review is a "work in progress" and therefore not complete. It is our desire that during the course of this joint Intercessional meeting, our colleagues will call our attention to other existing data and literature sources that we have overlooked.

Table 1.--Length on weight relationships; includes available sex-specific values.

SPECIES	Length on Weight Relationship	Sex	r^2	s.e.	n	Minimum weight	Maximum weight
North Pacific striped marlin							
central North Pacific	[a]**EFL** = 51.3506**W**$^{0.300417}$	pooled	0.840	6.365	1427	8.1	99.8
	[a]**EFL** = 50.9618**W**$^{0.301733}$	females	0.846	6.253	630	6.8	99.8
	[a]**EFL** = 52.8873**W**$^{0.293434}$	males	0.721	6.534	671	8.1	80.3
North Pacific swordfish							
central North Pacific	[b]**EFL** = 47.2751**DW**$^{0.29451}$	pooled	0.940	6.010	1550	22.8	262.6
	(Regression determined, results not available)	females					
	(Regression determined, results not available)	males					
Pacific blue marlin							
central North Pacific	[a]**EFL** = 52.0203**W**^0.283377	pooled	0.929	8.182	154	10.4	381.1

Striped marlin were measured for eye-to-fork length (**EFL**, cm) and whole weight (**W**, kg) at the auction.
Pacific blue marlin were measured for eye-to-fork length (cm) and whole weight (kg) at the auction.
Swordfish were measured for eye-to-fork length (cm) on ship and dressed weight (**DW**, kg) at the auction.

Literature Reference (Table 1)

[a]Uchiyama, J. H. and T. K. Kazama. 2003. Updated weight-on-length relationships for pelagic fishes caught in the central North Pacific Ocean and bottomfishes from the Northwestern Hawaiian Islands. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, NOAA. Administrative Report H-03-01. pp34, ppA-6.

[b]Uchiyama, J. H., E. E. DeMartini, and H. A. Williams. 1999. Length-weight interrelationships for swordfish, *Xiphias gladius* L., caught in the central North Pacific. U. S. Dep. Commer. NOAA Tech. Memo. NOAA-TM-NMFS-WSFSC-284. pp 82.

[c]Unpublished data.

Table 2.--Weight on length relationships; includes sex-specific values when available.

SPECIES	Weight on Length Relationships	Sex	r^2	s.e.	n	Minimum length	Maximum length
North Pacific Striped Marlin							
central North Pacific	[a]**W** = (-6.02372) - 0.0647304**EFL** + 0.0021165**EFL**$^{2.01602}$	pooled	0.802	4.7532	1427	100.3	198.0
	(Regression done, results not available)	female					
	(Regression done, results not available)	male					
eastern North Pacific	[c]**W** = -5.005(ln**EFL**)$^{2.999}$	male	0.7691		975	119.6	202.6
	[c]**W** = -5.166 (ln**LJFL**)$^{2.903}$	male	0.6084		220	172.0	261.0
	[c]**W** = -5.243(ln**EFL**)$^{3.113}$	female	0.7293		1007	110.0	215.1
	[c]**W** = -5.267(ln**LJFL**)$^{2.950}$	female	0.6053		315	153.0	271.0
	[c]**W** = -5.157 (ln**EFL**)$^{3.071}$	pooled	0.7465		1982	110.0	215.1
	[c]**W** = -5.340 (ln**LJFL**)$^{2.982}$	pooled	0.6147		535	153.0	271.0
eastern North Pacific	[d]**W** = 0.00009727**EFL**$^{2.5682}$	pooled	0.53		1748	107.5	225.5
North Pacific Swordfish							
western North Pacific	[e]**W** = 0.0000013528**LJFL**$^{3.4297}$	pooled	0.9664		227		
central North Pacific	[f]**W** = 0.000012988**EFL**$^{3.0738}$	pooled	0.967	7.9396	166	69.9	228.8
	(Regression determined, results not available)	female					
	(Regression determined, results not available)	male					
	[f]**DW** = 0.00000796012**EFL**$^{3.1307}$	pooled	0.931	9.3	1550	112.0	249.0
	(Regression determined, results not available)	female					
	(Regression determined, results not available)	male					
eastern North Pacific	[g]**W** = 0.0000137**EFL**$^{3.04}$	female	0.96		77		
	[g]**W** = 0.00000662**EFL**$^{3.19}$	male	0.97		29		
Pacific Blue Marlin							
central North Pacific	[a]**W** = 0.00000272228**EFL**$^{3.30967}$	pooled	0.932	13.446	154	109.2	269.3
central North Pacific	[h]**W** = 0.0000708**LJLF**$^{2.60}$	male			102	127.0	274.0
	[h]**W** = 0.0000001**LJFL**$^{3.81}$	female			55	141.0	342.0
eastern North Pacific	[c]**W** = -5.690(ln**EFL**)$^{3.318}$	female	0.8987		57	154.0	265.1
	[c]**W** = -7.543(ln**LJFL**)$^{3.905}$	female	0.9101		20	221.1	347.3

Striped marlin were measured for eye-to-fork length (**EFL**, cm), lower jaw fork length (**LJFL**, cm), and whole weight (**W**, kg) at the auction.
Pacific blue marlin were measured for eye-to-fork length (cm), lower jaw fork length (cm) and whole weight (kg) at the auction.
Swordfish were measured for eye-to-fork length (cm) on ship and dressed weight (**DW**, kg) at the auction.

Literature Reference (Table 2)

[a]Uchiyama, JH and TK Kazama. 2003. Updated weight-on-length relationships for pelagic fishes caught in the central North Pacific Ocean and bottomfishes from the Northwestern Hawaiian Islands. NMFS, PIFSC, NOAA. Adm Rpt H-03-01 pp34, ppA-6.

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[e]Sun CL, SP Wang, and SZ Yeh. 2003. Age and growth of the swordfish (*Xiphias gladius* L.) in the waters around Taiwan determined from anal-fin rays. Fish. Bull. U.S. 100(4): 822-835.

[f]Uchiyama JH, EE DeMartini, and HA Williams. 1999. Length-weight interrelationships for swordfish, *Xiphias gladius* L., caught in the central North Pacific. U.S. Dep. Commer. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-284. pp.82.

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Table 3.--Age & growth and natural mortality estimates; includes sex-specific values when available.

SPECIES	VB Growth Rate Model	Sex	Maximum Age	Maximum Length	Longevity	Natural Mortality Rates
North Pacific Striped Marlin						
western North Pacific						
central North Pacific	[b] $FL_t = 277.4(1-e^{-0.417(t+0.521)})$	male	4			[j]0.79; [k]0.569
	[b] $FL_t = 251.0(1-e^{-0.696(t-0.136)})$	female	5			[j]1.33; [k]0.818
eastern North Pacific	[c] $LJFL_t = 221(1-e^{-0.23(t+1.6)})$	pooled	11			
North Pacific Swordfish						
western North Pacific	[d] $LJFL_t = 267.44(1-e^{-0.13(t+2.302)})$ [standard vonB, model II]	female	12	[n]290cm LJFL	[n]21 yr	
western North Pacific	[d] $LJFL_t = 207.52(1-e^{-0.198(t+1.955)})$ [standard vonB, model II]	male	10	[n]206 cm LJFL	[n]13 yr	
central North Pacific	[f] $EFL_t = 258.3(1-e^{-0.192(t+1.59)})$	female	14	259 cm EFL		
central North Pacific	[f] $EFL_t = 222.2(1-e^{-0.240(t+1.49)})$	male	11	229 cm EFL		
eastern North Pacific	[g] $EFL_t = 263.7(1-e^{-0.1162(t+4.05)})$	female	9+			
eastern North Pacific	[g] $EFL_t = 273.2(1-e^{-0.077(t+3.20)})$	male	7+			
Pacific Blue Marlin					[i]>15yr	
western North Pacific						
central North Pacific	[b] $FL_t = 371.1(1-e^{-0.285(t+0.106)})$	male	5			
	[b] $FL_t = 659.1(1-e^{-0.116(t-0.161)})$	female	8			
eastern North Pacific						

Literature Reference (Table 3)

[b]Skillman RA and MYY Yong. 1976. Von Bertalanffy growth curves for striped marlin, *Tetrrapturus audax* , and blue marlin, *Makaira nigricans* , in the central North Pacific Ocean. Fish. Bull. U.S. 74(2):553-566.

[c]Melo Barrera FN, R Felix Uraga, C Quinonez Velazquez. 2003. Growth and length-weight relationship of the striped marlin, Tetrapturus audax (Pisces: Istiophoridae), in Cabo San Lucas, Baha California Sur, Mexico. Ciencias marinas 29(3):305-313

[d]Sun CL, SP Wang and SZ Yeh. 2003. Age and growth of the swordfish (*Xiphias gladius* L.) in the waters around Taiwan determined from anal-fin rays. Fish Bull U.S. 100(4): 822-835

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[g]Castro-Longoria, R. 1995. Analisis de edad, crecimiento y madurez del recurso pesquero del pez espada, Xiphias gladius, en el pacifico Mexicano. Tesis que para cubrir parcialmente los requisitos necesarios para obtener el grado de Doctor en Ciencias presenta. Division de Oceanologia, Departameneto de Ecologia. Centro de Investigacion Cienstifica y de Educacion Superior de Ensenada. pp.114.
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[j]Boggs CH. 1989. Vital rate statistics for billfish stock assessment. *In* : R. H. Stroud (editor), Planning the future of billfishes: Research and management in the 90s and beyond. Proceedings of the Second International Billfish Symposium, Kailua-Kona, Hawaii, August 1-5, 1988. Part I: Fishery and Stock Synopses, Data Needs and Management. Marine Recreational Fisheries 13:225-234.
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Table 4.--Information on sexual maturity, fecundity, and spawning season; includes sex-specific values when available.

SPECIES	Age at 1st / 50% Maturity	Size at 1st / 50% Maturity	Sex	Fecundity	Spawning Season
North Pacific Striped Marlin					
western North Pacific					[h]April-June
central North Pacific					[j]April-May **rare**
eastern North Pacific		[a]168.16 cm LJFL	female		[i]June-November
		[b]between 155-165 cm EFL	female	[b]11-29 x 10^6	
North Pacific Swordfish					
western North Pacific		[c]168.2 cm LJFL	female		not in Taiwan fishery [f]February-March to July-August
central North Pacific		[d]144.0 cm EFL	female	[e]3.0-6.2 x 10^6/batch	[d]April-July
central North Pacific		[d]102.0 cm EFL	male		
eastern North Pacific			female		
Pacific Blue Marlin					
western North Pacific					[h]April-June year-round near equator
central North Pacific					[g]May-September [j]July-September
eastern North Pacific					

Literature Reference (Table 4)

[a]Klette Traulsen, A. and S. Rodriques Rodriguez. [?] Contribution to study of the striped marlin gonadic development *Tetrapturus audax* (Philippi, 1887).

[b]Eldridge, MB and PG Wares. 1974. Some biological observations of billfishes taken in the eastern Pacific Ocean. *In* Shomura, RS and FW Williams (eds) Proc of the Int Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972, Part 2 Review and contributed papers. NOAA Tech Rep NMFS SSRF-675. pp89-101.

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[i]Gonzalez-Armas R, R Funes-Rodriguez, and VA Levy-Perez. 1993. First record of *Tretrapturus audax* larvae (Scombroidei: Ostiophoridae) in the coast of Jalisco, eastern Pacific of Mexico.

[j]PIFSC, unpublished data

Table 5.--Distribution by life stage and documented movements.

SPECIES	Early Life Stage Distribution	Adult Geographic Range	Adult Vertical Distribution	Documented Movements
North Pacific Striped Marlin				
western North Pacific	[a, b, c]up to 31°N in the southern Kuroshio Current	[c, h]up to southern Kuril Isles	[p]0-900m; 3-27°C	
central North Pacific	[d]Hawaiian Islands (Kona coast)	[c]up to 30°N	[q]>85% in mixed layer <90m depth; max depth down to depth related to 8°C<SST	[d]100 miles difference between release and recapture positions after about 1 yr.
eastern North Pacific	[e]mouth of Gulf of California	[c, i]10-40°N	[r]down to thermocline depth	[t]general trend south and southwest from tip of Baha California NW to California and one to SW of Hawaii
	[f]Marias Islands (Mexico/Pacific)			[u]Eight from Southern California to Hawaii
North Pacific Swordfish				
western North Pacific	[b, g]up to 31°N 132°E	[b, h, j]southern Kuril Isles		
central North Pacific	[d]Hawaiian Islands; Northwestern Hawaiian Is.	[j, k, l]11-40°N	[d]diurnal pattern; deep in day, >720m max; shallow at night -- <160m	[d]mostly N-S within fishing ground; few went east within fishing ground; one went to Los Angeles Bight
	[g]Musician Seamounts			
eastern North Pacific	none	[j, m]0-40°N	[r]100m max due to oxycline	
Pacific Blue Marlin				
western North Pacific	[a]wide spread <29°N	[h]southern Kuril Isles [n, o]10-43°N		
central North Pacific	[d]Hawaiian Islands	[n-o]10-40°N	[s]Most <200m, half <10m ≥17°C (tem @209m) [q]>85% in mixed layer; max depth down to depth related to 8°C<SST	[d]Kona to tip of Baha California Mexico (3); Kona to 1000m S (1); many local movements
eastern North Pacific	none	[n, o]0-42°N		

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