

## A Comparative Study on the Principal Dimensions of the Tuna Purse Seiners in the Pacific off Mexico and the USA

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The dimensional parameters of the tuna purse seiners in the Pacific off Mexico and the USA were investigated. The principal dimensions used in the present study were length overall (Loa), breadth (B), depth (D), gross tonnage (GT) and horsepower (HP). The coefficients and average values of the principal dimensions of the Mexican and USA vessels were calculated and compared. The coefficients obtained for the Mexican fleets were:  $B/Loa=0.191$ ,  $D/Loa=0.0873$ ,  $GT/(Loa \times B \times D)=0.107$  and  $HP/GT=6.96$ , for the USA fleets:  $B/Loa=0.174$ ,  $D/Loa=0.0782$ ,  $GT/(Loa \times B \times D)=0.106$  and  $HP/GT=6.47$ . The results showed that the Loa, B, D, GT, and HP averages of the Mexican purse seiners were 22.5, 8.1, 2.1, 19.6, and 18.5% greater, respectively, as compared with those of the USA seiners. The volume ( $Loa \times B \times D$ ) of the USA seiners was equal to that of the Mexican fleets, while the HP of the USA vessels was 7.6% less than that of the Mexican fleets. The USA purse seiners have a more slender and hydrodynamic form; the length overall of the USA seiners is greater than that of the Mexican fleets and the  $B/Loa$  is lower. These obtained results are useful for designing and constructing future Mexican tuna purse seiners and for better exploiting the Mexican tuna resource and rationalizing the fishing intensity of the world tuna fisheries in the future.

### 1 Introduction

The Mexican tuna catch in 1995 was 149,136 tons, more than that the 128,000 tons recorded in 1994 (Instituto Nacional de Pesca (INP), 1995). For Mexico, Mazatlan in the Pacific has become the most important tuna port (IATTC, 1995).

The Mexican Pacific tuna purse seiner was built in different shipyards around the world such as Poland, Italy, USA, etc. The recent purse seiner is a floating coldstorage equipped with many operat-

ing and living facilities for four months or more of operation. Diesel motors with a HP of 2,900-3,900 ps attains a velocity of about 16 knots. The operating crew of the fleet numbers about 25. It is provided with five to eight auxiliary speed boats and a helicopter. In general, a net with about a 1,500 m float line length used; a net height in the water is about 180 m. This carries a small mesh net of  $1\frac{1}{4}$ " (3.1 cm), which is the "dolphin safety panel" to reduce dolphin mortality.

Although general data for the Mexican vessel

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are available, the principal dimensions of the tuna purse seiners had never been previously analyzed. The principal dimensions and its coefficients for the vessels should be analyzed and evaluated

The objective of the present study is to provide basic indicators for planning the improvement, constructing the future Mexican tuna seiners and rationalizing the world tuna fishing. Information about the fishing machines and gears used is also presented.

## 2 Materials and methods

Dimensional parameters for the Mexican fleets were calculated on the basis of the following data:

(1) the trawl net and purse seine census undertaken in 1988 by the Dirección General de Infraestructura Pesquera, Secretaria de Pesca (SEPESCA, 1993), and

(2) the Mexican registers of Delegaciones Federales of the States in 1989 (Estado de Baja California, 1990, Estado de Sinaloa, 1991, Estado de Colima, 1992), and the Instituto Nacional de Pesca (INP, 1994, 1996)

On the other hand, the dimensional parameters for the USA vessels was calculated from the following data: the historical register of the tuna purse seiner of the annual report of the Inter-American Tropical Tuna Commission (IATTC, 1993).

The evolutional analysis about length overall was carried out using the data from 1970 to 1995 in Mexico and the USA.

The principal dimensions adopted in this study were length overall (Loa, m), breadth (B, m), depth (D, m), gross tonnage (GT, ton) and horsepower (HP, ps) according to Machii and Nose (1989).

The coefficients of B/Loa, D/Loa, GT/(Loa x B x D), HP/GT and the average values of the principal dimensions were compared between the Mexican Pacific fleets and the USA ones.

Other factors about fishing machines and gears were also compared between both countries fleets.

## 3 Results and discussion

### 3.1 Brief evolution of the Mexican tuna purse seiner

Tuna fishing by large Mexican fleets that began to appear at the end of the 1960's had a total GT of  $46.3 \times 10^3$  (Table 1). Temporal fluctuations in the total GT may be explained by the transfer of a part of the fleet to the Western Pacific in 1982. They returned to the Eastern Pacific in 1985 followed by the addition of new vessels in 1987 (SEPESCA, 1993). The Mexican historical data showed that during the 1990's the number of vessels and total GT suffered a decline (Table 1); 77 vessels in 1990 decreased to 56 in 1994 (INP, 1994).

Table 1. Evolution of the total GT in the Mexican Pacific purse seiners

Year	Total GT ( $\times 10^3$ )
1960	46.3
1976	184.6
1981	187.5
1982	170.0
1983	143.7
1984	116.5
1985	132.2
1986	126.1
1987	145.7
1988	151.5
1989	139.6
1990	67.0
1991	60.0
1992	50.0
1993	43.0
1994	40.3

Table 2. Coefficient of the principal dimensions obtained from the tuna purse seiner

Coefficients	(a) Mexican Pacific	(b) USA Pacific
B/Loa	0.191	0.174
D/Loa	0.0873	0.0782
GT/(Loa x B x D)	0.107	0.106
HP/GT	6.96	6.47

Loa: Length Overall, B: Breadth, D:Depth, GT: Gross Tonnage and HP: Horsepower.

### 3.2 Comparison of the coefficients and average values of the principal dimensions of the tuna purse seiners between the Mexican and the USA Pacific fleets

**Overall length (m):** The annual change in the Loa of the Mexican purse seiners is illustrated in Fig. 1-(a). In Mexico, two different groups were defined; the first ranges between 20 and 45 m (average, 30.2 m), and the second, 46 to 73 m (average, 66.5 m). In the USA, two groups were represented (Fig. 1-(b)); the first was found between 30 and 40 m (average, 33.8 m), while the second was in the range of 53 to 79 m (average, 70.8 m). The Loa average for the USA vessels was 22.5% greater than that for the Mexican Pacific.

**Breadth (m):** The B/Loa coefficient for USA vessels was 9.8% less than that for the Mexican Pacific fleets (Table 2-(a) and (b)). This coefficient for the Mexican Pacific vessels has remained unchanged for the last 20 years. In Mexico, two groups of B values were observed (Fig. 2-(a)). The first was from 6 to 10 m and the second was from 10.5 to 13.5 m. The B values in the USA were also represented by two groups: the first with an average of 7.9 m, and the second with average of 12.2 m (Fig. 2-(b)). The average values of B for the USA Pacific vessels were 8.1% greater as compared with those for the Mexican Pacific (Figs. 2-(a) and (b)).

**Depth (m):** As for the D/Loa, the Mexican Pacific vessel was 11.6% larger than that of the USA (Tables 2-(a) and (b)). In Mexico, two groups of D were found (Fig. 3-(a)); the first was from 2.7 to 5.0 m and the second from 5.0 to 6.2 m. In the USA, the D values are illustrated in Fig. 3-(b), and two groups are also found: the first having an average of 3.4 m and the second, 5.5 m. The D averages were almost the same (2.1% greater) between the USA vessels and the Mexican ones (Figs. 3-(a) and (b)).

**Gross Tonnage (ton):** the GT/(LoaxBxD) coefficients of the USA vessels was equal to that of the Mexican (Table 2-(a) and (b)). In Fig. 4-(a), two

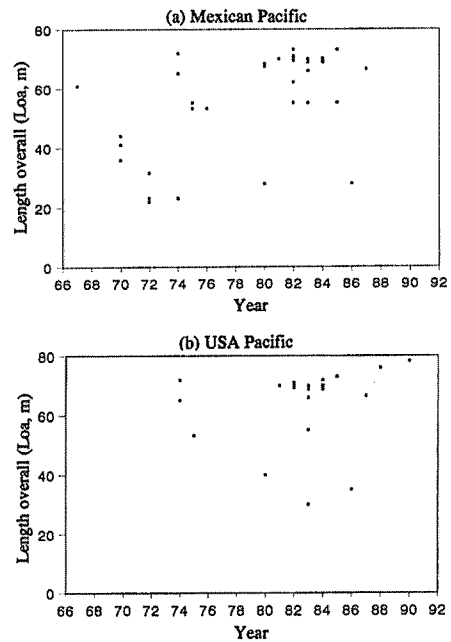


Fig. 1. Change in overall length of the tuna purse seiner.

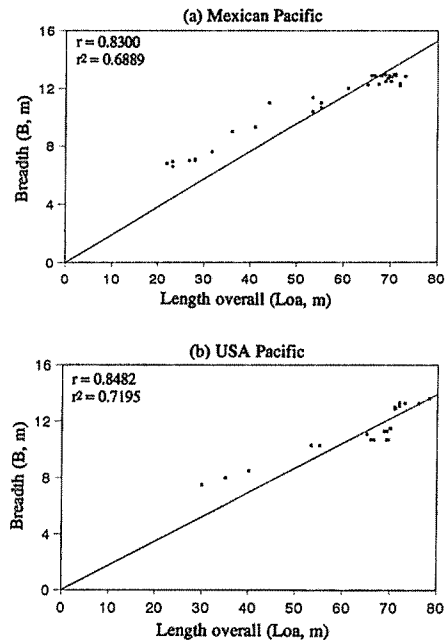


Fig. 2. Relationship between overall length and breadth of the tuna purse seiner.

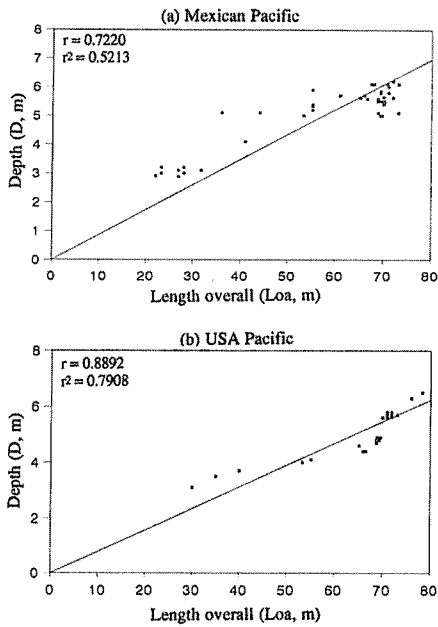


Fig. 3. Relationship between overall length and depth of the tuna purse seiner.

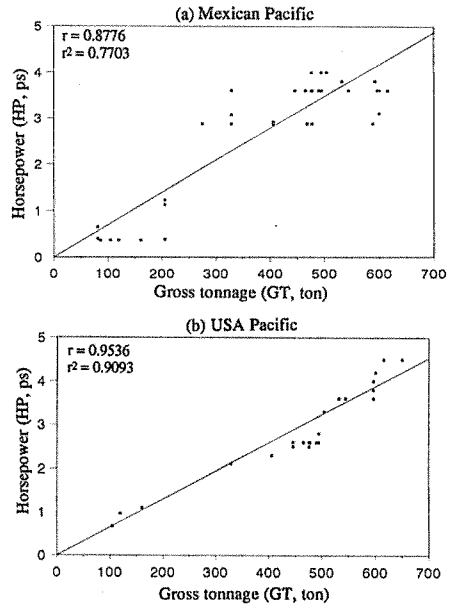


Fig. 5. Relationship between gross tonnage and horse power of the tuna purse seiner.

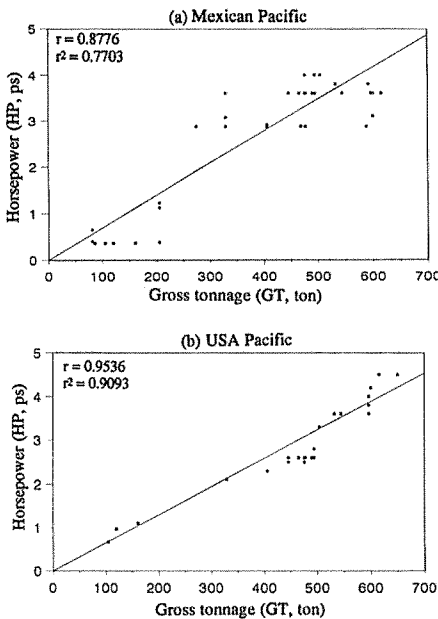


Fig. 4. Relationship between volume and gross tonnage of the tuna purse seiner.

Table 3. Principal dimensions obtained from the tuna purse seiner

Loa (m)	B (m)	D (m)	GT (tons)	HP (ps)
(a) Mexican Pacific				
30	5.73	2.61	48	334
35	6.69	3.05	76	530
40	7.64	3.48	114	791
45	8.60	3.92	162	1127
50	9.55	4.35	222	1548
55	10.51	4.79	296	2057
60	11.46	5.22	384	2671
65	12.42	5.88	488	3396
70	13.37	6.09	610	4242
75	14.33	6.53	750	5217
(b) USA Pacific				
30	5.22	2.34	39	251
35	6.09	2.73	62	399
40	6.96	3.12	92	596
45	7.83	3.51	131	849
50	8.70	3.90	180	1164
55	9.57	4.29	239	1549
60	10.44	4.68	311	2011
65	11.31	5.07	395	2557
70	12.18	5.46	493	3194
75	13.05	5.85	607	3929
80	13.92	6.24	737	4768

different groups for the Mexican fleets are represented; the first ranging from 80 to 400 tons and the second from 440 to 630 tons. The GT values in the USA are also distinguished by two groups (Fig. 4-(b)); the first, an average of 167 tons and the second, 547 tons. The greater frequency in the USA ranged from 480 to 650 tons representing about 80% of the total vessels, while 60% of the Mexican Pacific vessels is distributed between 440 and 630 tons. The GT average of USA vessels was 19.6% greater compared with that of the Mexican Pacific fleets (Figs. 4-(a) and (b)).

Horsepower (ps): The coefficient HP/GT, for the Mexican Pacific vessels, was 7.6% larger than that for the USA (Tables 2-(a) and (b)). The greatest Mexican frequency was found between 2,800 and 4,000 ps, which represented 62.5% (Fig. 5-(a)). The HP values in the USA are shown by two groups (Fig. 5-(b)); the first, an average of 1,100 ps and the second, 4,500 ps. The average HP value for the USA Pacific vessels was 18.5% greater than that for the Mexican Pacific ones.

The principal dimensions were calculated based on the coefficients obtained (Table 3). The principal dimensions of the USA vessels presented less values than those of the Mexican Pacific ones. The three Mexican representative vessels are listed in Table 4-(a). A progressive increment in GT and HP was found; 375 tons/2,900 ps, 446 tons/3,600 ps and 470 tons/3,900 ps in 1970, 1980 and 1988, respectively. The modern purse seiners in 1988 are faster when compared with the 1970 boats. In two cases, the propeller diameter reprincipaled constant with time while the pitch and r.p.m. values become lower, indicating the same propulsion efficiency.

The USA vessels with a more slender and hydrodynamic form became popular around 1990. This results in increasing the total working deck area which is about 1.4 times larger than that in 1970 (Table 4-(b)). Although the length overall became greater, the B/Loa was reduced; the USA tuna seiners became bigger and faster. The USA

propulsive efficiency was improved, and this results in increasing the boat's cruising velocity. It has been reported (Tuna 91, 1991) that purse seiners with a high speed, increase their catch and reduce the number of catchless settings.

### 3.3 Characteristics of the fishing machines and purse seines in the Mexican Pacific and USA Pacific fleets

The characteristics of the typical fishing machines and gears of the Mexican and USA Pacific purse seiners have varied with time and are listed for each period of their construction (Tables 4-(a) and (b)).

While the float line length of the Mexican purse seines has increased from 1,350 to 1,640 m, the Mexican HP of the purse winch has remained constant. The HP of the USA purse winch increased linearly with increasing float length of the purse seine.

The USA modern purse seiner began to operate in 1990, with the following characteristics:

- 1) the purse winches of the new models have a large cable capacity.
- 2) the winch horsepower increased about twice since 1970.
- 3) the power block pull at 1/2 radius increased about 3.6 times since 1970.

## 4 Conclusion

The Mexican GT/HP/Net (representing the float line length) changes are shown: 375 ton /2,875 ps/1,350 m, 446 ton/3,600 ps/1,460 m, and 470 ton/3,900 ps/1,640 m in 1970, 1980 and 1988, respectively.

All the coefficients obtained for the Mexican tuna purse seiners were greater than those of the USA. This results in greater operating costs in the Mexican fleets, especially fuel oil cost.

The USA tuna purse seiner was built for moving quickly for efficiently searching tuna shoals.

Table 4. Evolution of the characteristics of tuna purse seiner

(a) Mexican Pacific

(b) USA Pacific

Fleet characteristics							
Fleet names	Indomable	Nahir	Azteca 2	—	—	—	—
Constructed year	1970	1980	1988	1970	1980	1988	1990
Constructed countries	Poland	USA	Italy	Campbell	Campbell	Campbell	Campbell
Length overall (Loa, m)	52.90	61.69	68.09	67.50	67.50	76.03	78.33
Breadth (B, m)	11.30	12.33	12.80	12.27	12.27	12.27	13.64
Depth (D, m)	5.20	5.40	5.18	5.12	5.12	5.90	6.26
Gross tonnage (GT, tons)	375	446	470	460	460	670	800
Capacity of fish hold (FH, m <sup>3</sup> )	650	900	1200	1200	1200	1550	1600
Total working deck area (m <sup>2</sup> )	180	200	220	220	220	320	310
Auxiliary speed boat No. and HP	5 (115ps)	7 (125ps)	8 (125ps)	8 (125 ps)	8 (125 ps)	10 (125 ps)	10 (125 ps)
Engine characteristics							
Horsepower (HP, ps)	2900	3600	3900	2800	3500	4000	4200
Propulsion efficiency	0.57	0.57	0.57	0.58	0.58	0.57	0.68
Velocity (knot)	12.5	14.0	16.0	16.0	16.0	15.5	17.5
Propeller characteristics							
Blade number	5	5	5	5	5	5	5
Diameter (m)	3.2	3.2	3.3	3.2	3.2	3.3	3.5
Pitch (m)	2.6	2.4	2.1	2.6	2.4	2.1	2.0
Revolution (rpm)	207	170	179	207	170	179	170
Electric power and Refrigeration system							
Generators (kw)	600	600	900	900	900	900	1400
Compressors (kw)	300	300	425	325	425	575	750
Fishing machine							
(1) Winch							
Type	W 1062	W 1062	WS 444	W 1062	WS 454	WS 455	WS 550
Hydraulic horse power (ps)	455	455	455	455	500	764	1000
Hauling force (kg)	19800	19800	22700	19800	36000	40000	60000
Cable diameter (mm)	19.05	19.05	19.05	19.05	22.00	25.00	30.00
Cable capacity (m)	2200	2200	3100	2200	2500	3400	4000
(2) Powered block							
Type	Marco 42-48	Marco B48	G 1990	Marco 42-48	Marco 56-135	Marco 56-190	Marco 56-81
Pull at ½ radius (kg)	17400	17400	26000	17400	32000	47000	62000
Fishing net (Tuna purse seine)							
Float line length (m)	1350	1460	1640	1300	1600	1800	1800
Net height in the water (m)	120	180	200	150	180	220	220

For the same GT, the HP of USA vessels was found to be 7.6% less than that of the Mexican Pacific.

These obtained results are useful for designing and constructing future Mexican tuna purse seiners and for better exploiting their resources and rationalizing the world tuna fishing intensity in the future.

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## メキシコと米国の太平洋岸マグロ旋網漁船の主要寸法の比較検討

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太平洋側で操業するメキシコと米国のマグロ旋網漁船の主要寸法を比較検討した。寸法として採用したのは、全長 (Loa,m), 幅 (B,m), 深さ (D,m), 総トン数 (GT,ton), 馬力 (HP,ps) の5要素である。現在操業中のそれぞれの国の船について、 $B/Loa$ ,  $D/Loa$ ,  $GT/(Loa \times B \times D)$ ,  $HP/GT$ の諸係数、および主要寸法の平均値を求め両国船を比較した。

メキシコ船はずんぐり型の船型であるのに対し、米国船は、メキシコ船より大型で、細長く、流線型であり、速度の向上に努めている。また、同じGTに対して、米国船のHPはメキシコ船より7.6%少なく(単位GT当たりのHPが小さい)、経済的であることが分かった(主として燃料)。ウインチやパワーブロックにしても、米国船は、旋網の大型化に対応して、大きくなっているが、最近のメキシコ船は、米国船のように改良を行っていない。上記諸係数や主要寸法の平均値は、メキシコにとって、直接的には、今後のマグロ旋網漁船の設計に、間接的には、国際マグロ漁業の漁獲強度の適正化に必要な基礎資料を準備することになるだろう。