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Northern Shrimp (*Pandalus borealis*, Krøyer) from Spanish Bottom Trawl Survey 2006 in NAFO Divisions 3LNO

by

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Abstract

The Spanish Institute of Oceanography carried out in 2007 two bottom trawl surveys in the NAFO Regulatory Area in Division 3NO and 3L during the months of June and August respectively. The results on northern shrimp (*Pandalus borealis*) are presented and compared with those from previous surveys from the same series. In 2007 the catch (71 kg.) and estimated biomass (401 tons.) confirm the decrease of shrimp importance from 2004 in 3NO. In 3L Division, since the beginning of the new survey in 2003 and after of years with consecutive and constant increase the estimated biomass in 2007 decreased about 10% with respect to last year.

Catch results from the surveys and data analysis are discussed in this paper.

Introduction

Northern shrimp (*Pandalus borealis* Krøyer, 1883) is a protrandric, circumpolar species, discontinuously distributed in the North Atlantic and of considerable commercial importance. The greatest abundance is being in the Northwest Atlantic at latitudes above 46ºN. The stock of this species in Div. 3LNO, NAFO is distributed along the entire edge of the grand banks, at depths generally ranging from 180 to 550 metres, although historically the 90-99% of the biomass had been attributed to NAFO Div. 3L (Orr *et al*, 2005).

Since 1995, Canadian multi-species stratified random surveys have been used to estimate northern shrimp biomass and abundance indices within NAFO Div. 3LNO. In this series of surveys, Div. 3N accounts for between 0.5 and 9% of the total biomass in Div. 3LNO; over 82% of the biomass in Div. 3N is located beyond the 200 mile limit (Orr *et al.*, 2003). The biomass in Division 3O accounts for less than 1% of the biomass in Div. 3LNO and only the 0.34% of the biomass in Div. 3O is beyond the 200 mile limit (Orr *et al*., 2003).

The Vigo Centre of Instituto Español de Oceanografía is conducting research cruises since 1995 in the NAFO Regulatory Area in Div. 3NO beyond the 200 mile exclusive economic zone. A stratified, random, bottom trawl, multi-species research sampling program was carried out to obtain abundance and biomass indices as well as other biological data for the most important commercial species present in the area.

In the surveys conducted between 1995 and 2000, the catches of northern shrimp were insignificant. This could be explained by the low efficiency of the fishing gear “pedreira”, with this species (Paz *et al*., 1995), used in those years.

Since 2001, the survey was carried out on board R/V “*Vizconde de Eza*” using a Campelen 1800 net (Walsh *et al*., 2001). Despite the improvements incorporated with the new vessel and the use of a Campelen 1800 net, which is highly efficient for this species (Vazquez, 2002), total catches in 2001 were poor, i.e., 28.8 kg.

From 2002 year a significant increase of the catches of northern shrimp was noted in 3NO Division with catches bigger than 300 kg.

Also, since 2003 a new research survey was conducted in Division 3L as an extension of the survey carried out in 3NO. The estimated biomass in 3L Division always was very superior to that estimated in 3NO.

This work presents data on the geographical distribution in the NAFO Regulatory Area (Div. 3LNO), on biomass, length frequencies, age structure and length-weight relationship of catches of northern shrimp on Spanish bottom trawl surveys 2007.

Materials and Methods

The 2007 Spanish bottom trawl surveys were carried out from the 29th of May to 19th of June in 3NO and from 23th of July to 11th of August in 3L, following set guidelines previously established for the series of I.E.O. research surveys (Walsh *et al.*, 2001). These surveys took place in Div. 3NO and 3L, with a total of 110 and 94 valid hauls respectively ranging depths between 40 and 1400 m approximately.

Shrimp samples of approximately 1.5 kg were taken to determine length frequencies in hauls where the amount and good condition of the specimens caught permitted to sample them.

Males and females were separated with reference to the endopodite of the first pleopod (Rasmussen, 1953). Following this criterion, individuals that were in the middle of a sex change were considered as females. The females were differentiated into mature and immature, following the sternal spines criteria (McCray, 1971). Ovigerous females were considered as an independent group not included within the mature females.

Individuals were measured onboard by noting the distance from the base of the eye to the posterior mid dorsal point of the carapace -OCL- (Shumway *et al*., 1985). Such measurements were made to the lower half millimetre using electronic callipers.

Furthermore, in 2007 survey some samples were frozen onboard to determine the length-weight relationship in the laboratory. 1095 and 4126 individuals were selected in 3NO and 3L Divisions respectively, dried and weighed with a precision of 0.1g to calculate the length-weight relationship in each Division.

Results and Discussion

The Table 1 shows the catches, biomass and standard errors estimated by swept area method of northern shrimp from the multi-species surveys, carried out by IEO Vigo from 1995-2007 in the NAFO Div. 3NO and from 2003-2007 in Division 3L. In the summer of 2005 the research survey could not be carried out in Division 3L. From the year 2002 an abrupt increase with respect to earlier years occurred in 3NO Division, both in terms of catch and biomass (Diaz *et al*., 2002). These initial data were considered with caution due to the fact that, until 2001, the "Pedreira" gear used as a sampler (Paz *et al*., 1995) was not efficient for catching shrimp. However, although in 2001, the gear "type Pedreira" was changed for a new type "Campelen 1800" (Walsh *et al*., 2001) with high efficiency for catching this species (Vazquez, 2002), the catches and biomass estimated stayed at low levels.

After 2002 year, the increase in northern shrimp catch in 3NO was confirmed, in terms of the period 1995-2001 although in the last three years both the catches and estimated biomasses of shrimp have decreased markedly with levels of biomass in 2007 around 400 t. (Figure 1).

Unlike 3NO, the estimated biomass in Division 3L since the beginning of the new survey in 2003 showed a constant and significant increase from 63647 t. in 2003 to 125850 t. in 2006. In 2007 maintaining with a estimated biomass of 113000 t. the increasing trend seems to be interrupted.

The distribution of northern shrimp catches in the Spanish trawl survey 2007 is shown in Figure 2. As in previous years the main catches were located at medium depths (184-366 m.) in Div. 3L. The residual catches in 3NO were mainly located to the Northeast of Div. 3N, in latitudes higher than 45ºN.

Table 2 and 3 show the shrimp biomass by depth strata from 1995 to 2007 surveys in Divisions 3NO and from 2003 to 2007 in 3L. Although it is considered that the shrimp in Div. 3LNO is distributed along the entire edge of the grand banks, at depths generally ranging from 100 to 300 fathoms (180-550 m.), the depth of the bulk of biomass present differences in 3L and 3NO Divisions. While in 3L Division practically the total of the biomass (>95%) were produced all years in depths lower than 200 ft., in 3NO the percentage of the estimated biomass in depths lower than 200 ft. varied along the years, showing a deeper distribution in 2004 and 2005 where the percentage of the shrimp catches in depths bigger than 200 ft. was around 74 and 66 % respectively.

The length distribution by sex estimated in the 3NO and 3L are presented in table 4 and figure 3. Although the range of their length distributions and main modes around 20 mm. and 23 mm. for males and females respectively did not show important differences in the two Divisions, in 3L was also present a clear mode around 17 mm. which it was practically absent in 3NO. Also the sex ratio was different in both Divisions, showing in 3L a higher percentage of the males.

The MIX modal size analysis programme was used with the length distribution by sex estimated in 3L. From the cited analysis the males presented three modes at 14.5 17.4 and 20.5 mm. corresponding with ages 2, 3 and 4 respectively. The sex change occurs at age 4 and the females showed a unimodal distribution. This mode included several age groups but the age 5 at 23.7 mm. stands out from the rest.

The Table 5 shows the length-weight relationship estimated in 2007 surveys by sex and maturity stage as well the parameters of the relationship, number of specimens sampled and determination coefficient R^2.

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Table 1. Northern shrimp biomass estimated by swept area (tons.), standard error and catches (kg.) from Spanish bottom trawl survey in NAFO Div. 3NO, 1995-2007 and 3L 2003-2007.

3NO			
Year	Biomass		Catch
	tons	Std. err.	(kg.)
1995[1]	14	13	5
1996[1]	18	17	2
1997[1]	1	1	0
1998[1]	23	17	5
1999[1]	81	36	13
2000[1]	26	9	6
2001[2]	178	72	29
2002[2]	2043	814	408
2003[2]	1618	716	325
2004[2]	2654	1693	550
2005[2]	1627	590	368
2006[2]	1274	352	278
2007[2]	401	312	71

3L			
Year	Biomass		Catch
	tons	Std. err	(kg.)
1995[1]			
1996[1]			
1997[1]			
1998[1]			
1999[1]			
2000[1]			
2001[2]			
2002[2]			
2003[2]	63647	20105	5836
2004[2]	94270	40332	5093
2005	Not surveyed		
2006[2]	125850	12690	17805
2007[2]	113052	19631	17609

[1] Pedreira codend 35 mm. mesh size.
[2] Campelen codend 20 mm. mesh size.

Table 2. Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 2001-2007 in NAFO Div. 3NO.

Division 3NO															
Stratum	Area miles^2	Depth range ft.	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
375	271	0-30	0	0		0	0	0	3453	0	25	0	0	1989	0
376	1334	0-30	0	0		0	0	0	1270	0	0	0	341	4203	0
353	269	31-50	0	0		0	0	0	79	0	48	0	0	0	126
360	2783	31-50	0	0		0	0	0	26423	1457	3470	24	0	0	445
374	214	31-50	0	0		0	0	0	178	0	0	0	0	0	62
354	246	51-100	0	0		0	0	0	87612	0	292	6917	0	0	14
359	421	51-100	0	0		0	1389	0	6348	847	1309	43	41	22	98
377	100	51-100	0	0		0	208	44	0	2020	751	1471	3742	3704	83
382	343	51-100		0		0	213	206		112695	302	297	825	944	191
355	74	101-150		0		0	0	0	15170	147	7635	6146	6183	9179	262
358	225	101-150	0	0		0	30129	0	717	3261	3900	10289	32548	258	2357
378	139	101-150	0	0		8968	10998	1196	17004	680353	11429	772	3985	10066	1357
381	144	101-150		0		63	11205	122		84984	20648	225280	1486	75176	303300
356	47	151-200		0		0	0	0	137	0	1337	12937	8046	2683	213
357	164	151-200	0	18097		0	0	0	606	16414	425145	163606	38796	114178	9307
379	106	151-200	0	0	720	0	135	0	12511	70342	254080	7709	329867	116970	12146
380	96	151-200		0		1024	9346	10240		1000960	698502	258603	120866	607392	6488
721	65	201-300		0		0	0	0	2889	3282	1112	852	256	3054	0
723	155	201-300		0		0	16872	0	0	12667	92831	44044	3333	53799	14615
725	105	201-300	14315	0		0	0	0	271	527	91803	1814540	748369	206794	47133
727	96	201-300		0		13213	0	11429		28660	2119	98477	326841	62635	1248
722	84	301-400		0		0	37	734	2890	60	156	0	36	0	0
724	124	301-400	0	0		0	0	0	0	55	628	58	165	53	213
726	72	301-400	0	0		0	0	0	0	7	54	2048	0	406	170
728	78	301-400		0		0	0	1671		7280	0	0	86	135	0
752	131	401-500		0		0	0	0		86	0	49	222	58	309
756	101	401-500		0		0	0	0	0	0	46	42	869	84	27
760	154	401-500		0		0	0	0	0	0	283	49	0	0	590
764	100	401-500		0		0	0	0	42	0	0	0	0	0	0
753	138	501-600		0		0	0	0		0	0	0	0	166	0
757	102	501-600		0		0	0	0		204	0	0	27	0	67
761	171	501-600		0		0	0	0	0	0	0	0	0	0	99
765	124	501-600		0		0	0	0	0	37	0	0	0	0	0
754	180	601-700				0	0	0		0	0	0	0	0	0
758	99	601-700				0	0	94		16302	0	19	88	0	0
762	212	601-700				0	0	0	0	85	0	0	0	0	
766	144	601-700				0	0	0		19	58	0	0	0	
755	385	701-800				0	0	89		0	174	0	68	0	0
759	127	701-800				0	0	0		17	0	48	0	0	
763	261	701-800				0	0	0		0	0	0	0	0	
767	158	701-800				0	0	0		0	0	0	0	0	
Biomasa (ton.)			14	18	1	23	81	26	178	2043	1618	2654	1627	1274	401
Std. Error (tons)			13	17	1	17	36	9	72	814	716	1693	590	352	312

Table 3. Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 2003-2007 in NAFO Div. 3L.

Division 3L							
Stratum	Area miles^2	Depth range ft.	2003	2004	2005	2006	2007
385	104	51-100	420	175		2485867	2416545
390	1481	51-100	1014	3780		2577958	5404325
389	821	101-150	14397492	41654297		53639329	49120205
391	282	101-150	1116135	1299793		3712072	12448106
387	718	151-200	17618619	21721973		29967360	11782827
388	361	151-200	25169595	24779540		32585066	26954928
392	145	151-200	2821419	1866379		193967	799970
729	186	201-300	20371	1465049		88481	172095
731	216	201-300	2449416	1467221		177357	666240
733	468	201-300		4077		390052	3281339
730	170	301-400	0	876		1485	76
732	231	301-400	34907	5643		14535	4723
734	228	301-400		408		10554	136
741	223	401-500	0	56		1379	22
745	348	401-500	17642	0		1699	186
748	159	401-500	292	696		366	499
742	206	501-600	0	0		462	0
746	392	501-600	0	0		134	0
749	126	501-600	0	23		99	0
743	211	601-700		0		1020	0
747	724	601-700		0		147	0
750	556	601-700		0		58	0
744	280	701-800		0		185	0
751	229	701-800				0	0
Biomasa (ton.)			63647	94270		125850	113052
Std. Error (tons)			27126	54044		15484	19631

Table 4. Northern shrimp size distribution (‘000) by sex from Spanish bottom trawl survey 2007 in NAFO Div. 3NO an 3L.

3NO			
OCL(mm)	**Males**	**Females**	**Total**
9			
9.5			
10			
10.5			
11	9		9
11.5	28		28
12	14		14
12.5	322		322
13	602		602
13.5	102		102
14	85		85
14.5	287		287
15	110		110
15.5	427	11	438
16	812	11	823
16.5	664	7	672
17	966		966
17.5	913	171	1083
18	1674	45	1719
18.5	1843	208	2051
19	1904	867	2771
19.5	2007	824	2831
20	2561	1372	3932
20.5	2759	2698	5457
21	1533	2274	3806
21.5	867	3997	4864
22	396	5466	5862
22.5	492	7575	8067
23		5009	5009
23.5		4719	4719
24		3036	3036
24.5		1830	1830
25		1623	1623
25.5		1661	1661
26		805	805
26.5		181	181
27		205	205
27.5		43	43
28		91	91
28.5		206	206
29	9		9
29.5			
30			
30.5			
31			
Total	21376	44933	66309
	32%	68%	

3L			
OCL(mm)	**Males**	**Females**	**Total**
8	2699		2699
8.5	4572		4572
9			
9.5			
10			
10.5			
11			
11.5			
12	27		27
12.5	4920		4920
13	15806		15806
13.5	76374		76374
14	90747		90747
14.5	89548		89548
15	145532		145532
15.5	166313		166313
16	388265		388265
16.5	650726		650726
17	808269	2071	810341
17.5	734466		734466
18	587922		587922
18.5	715377	7468	722845
19	782370	17108	799478
19.5	1013329	36729	1050058
20	1271550	111091	1382641
20.5	1216834	191004	1407837
21	1020826	392537	1413363
21.5	604009	669843	1273852
22	429376	771401	1200777
22.5	180178	911367	1091546
23	86821	1087290	1174111
23.5	40073	1129628	1169701
24	13963	940705	954669
24.5	3109	863690	866798
25	219	599134	599353
25.5		358879	358879
26		253284	253284
26.5		145676	145676
27		71974	71974
27.5		32120	32120
28		22612	22612
28.5		6223	6223
29		1874	1874
29.5		437	437
30		83	83
30.5			
31		1445	1445
Total	11144218	8625674	19769892
	56 %	44 %	

Table 5. Northern shrimp length-weight relationship by sex, maturity stage and all combined from Spanish bottom trawl survey 2007 in NAFO Div. 3NO and 3L

Division 3NO				
	a	b	R^2	N
Males	0.12117	2.65324	0.93031	326
Inmature females	0.00569	2.2831	0.62834	349
Mature females	0.00152	2.70454	0.75434	257
All combined	0.00185	2.63897	0.94928	1095

Division 3L				
	a	b	R^2	N
Males	0.00117	2.76151	0.96001	1984
Inmature females	0.00094	2.84776	0.90663	568
Mature females	0.00088	2.85489	0.85233	1040
Ovigerous females	0.00210	2.60970	0.71967	534
All combined	0.00086	2.87160	0.96411	4126

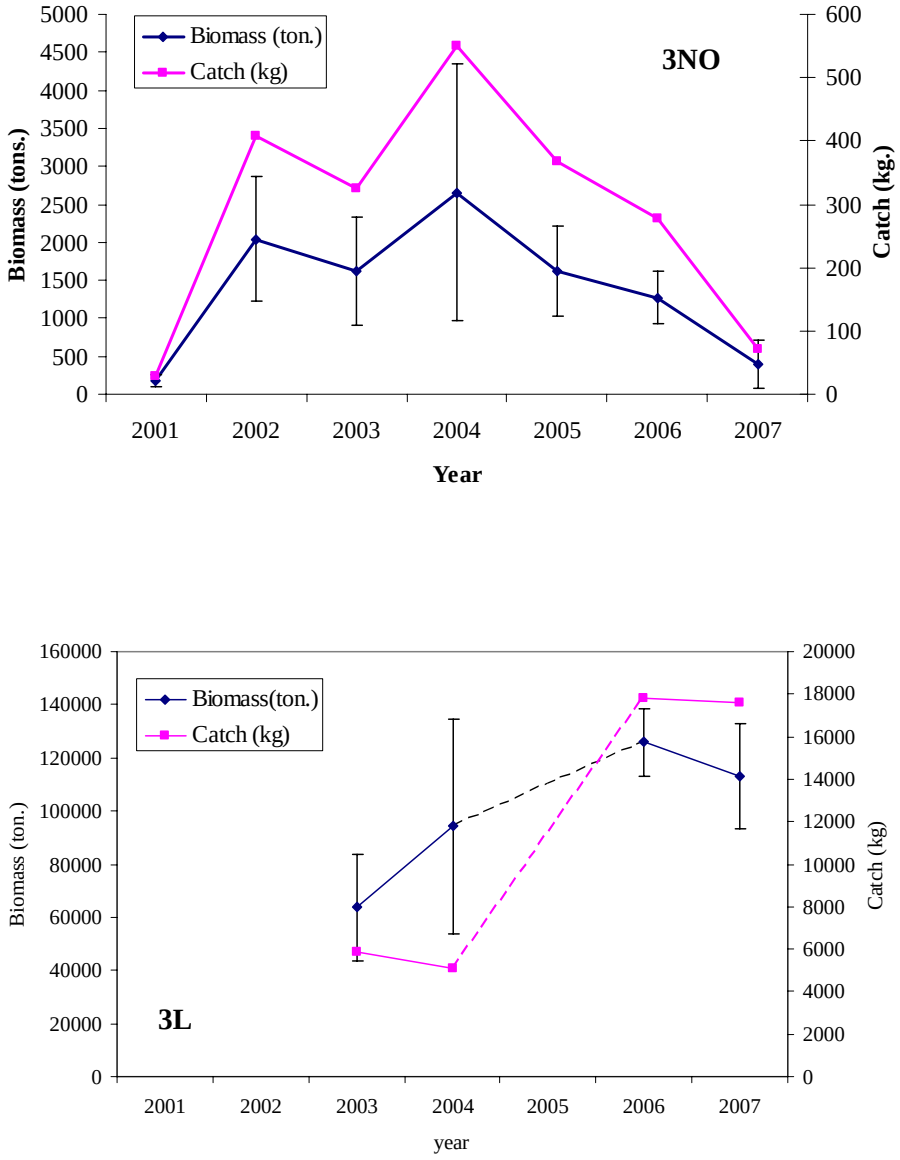

Figure 1. Northern shrimp biomass (tons) and catch (kg) from Spanish research surveys in NAFO Div. 3NO 2001-2007 and 3L 2003-2007.

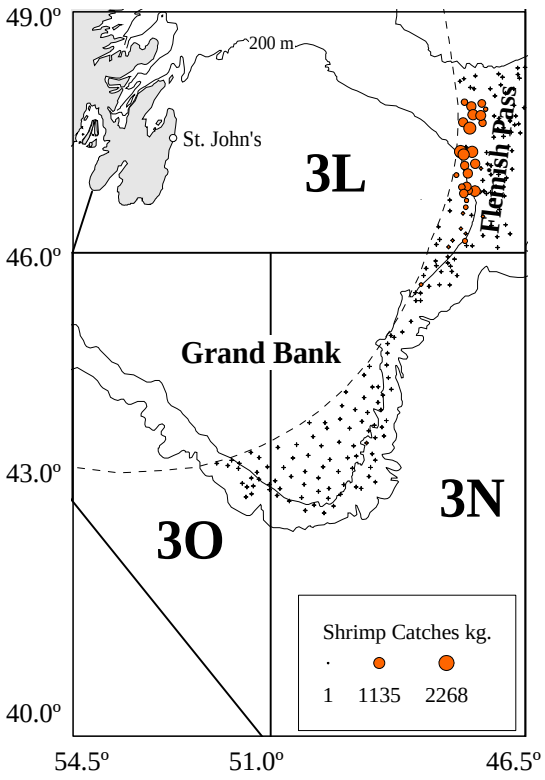

Figure 2. Geographic distribution of Northern shrimp catches from Spanish bottom trawls surveys 2007.

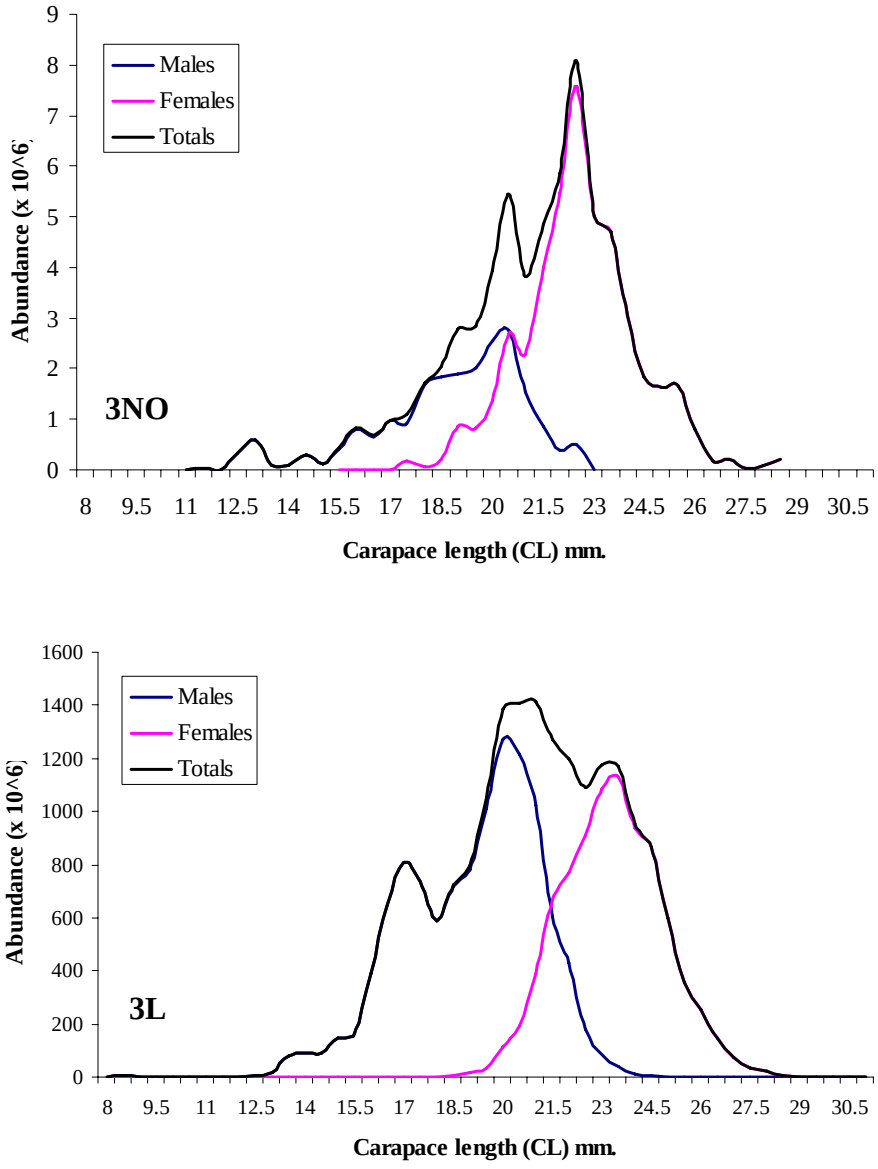

Figure 3. Northern shrimp size distribution, by sex from Spanish bottom trawl surveys in Div. 3NO and 3L.