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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 2006 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. While the catch (278 kg.) and estimated biomass (1300 tons.) confirm the decrease of shrimp importance from 2002 in 3NO, 3L showed since the beginning of the new survey in 2003 a constant and significant increase from 104551 tons. in 2003 to 215389 tons. in 2006.

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 mean weight by length-class of catches of northern shrimp on Spanish bottom trawl surveys 2006.

Materials and Methods

The 2006 Spanish bottom trawl surveys were carried out from the 7th to 27th of June in 3NO and from 1st to 20th 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 120 and 100 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 2006 survey some samples were frozen onboard to determine the length-weight relationship in the laboratory. 2803 and 5256 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 1995-2006 in the NAFO Div. 3NO and from 2003-2006 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 two years both the catches and estimated biomasses of shrimp show a decreasing trend with levels in 2006 around 1300 t. (Fig. 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 104551 t. in 2003 to 215389 in 2006.

The distribution of northern shrimp catches in the Spanish trawl survey 2006 is shown in Fig. 2. 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 2006 surveys in Divisions 3NO and from 2003 to 2006 in 3L. From 2003 the bulk of estimated biomass (>90%) were allocated at depths between 150-300 ft. (270-550 m.). 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. In 3L Division practically the total of the catches (>95%) were produced in depths between 150 ft. and 200 ft. while in 3NO Division the catches increased from depths between 100 and 200 ft. during the years 2001-2003 (around 90%) to depths between 200 and 300 ft. in the three last years.

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 19.5 mm. and 24 mm. for males and females respectively did not show important differences in the two Divisions, the youngest males (10-15 mm.) were in percentage terms more important in 3NO. Also the sex ratio was very different in both Divisions, showing values next to 50% in 3NO while in 3L the importance of males was very superior (71%).

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 15.7 18.9 and 21 mm. corresponding with ages 2, 3 and 4 respectively. The sex change occurs at age 4 and the females showed a bimodal distribution with a weak mode at 19.2 mm (age 3) and a strong mode at 24 mm. This mode includes several age groups but the age 5 with lengths around 24 mm. stands out from the rest.

The Table 5 shows the length-weight relationship estimated in 2006 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, 1995-2006 and 3L 2003-2006.

3NO			
Year	Biomass		Catch (kg.)
	tons	Std. err.	
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

3L			
Year	Biomass		Catch (kg.)
	tons	Std. err	
1995[1]			
1996[1]			
1997[1]			
1998[1]			
1999[1]			
2000[1]			
2001[2]			
2002[2]			
2003[2]	104551	37403	5836
2004[2]	159289	65867	5093
2005	Not surveyed		
2006[2]	215389	21161	17805

[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 2001-2006 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
375	271	0-30	0	0		0	0	0	3453	0	25	0	0	1989
376	1334	0-30	0	0		0	0	0	1270	0	0	0	341	4203
353	269	31-50	0	0		0	0	0	79	0	48	0	0	0
360	2783	31-50	0	0		0	0	0	26423	1457	3470	24	0	0
374	214	31-50	0	0		0	0	0	178	0	0	0	0	0
354	246	51-100	0	0		0	0	0	87612	0	292	6917	0	0
359	421	51-100	0	0		0	1389	0	6348	847	1309	43	41	22
377	100	51-100	0	0		0	208	44	0	2020	751	1471	3742	3704
382	343	51-100		0		0	213	206		112695	302	297	825	944
355	74	101-150		0		0	0	0	15170	147	7635	6146	6183	9179
358	225	101-150	0	0		0	30129	0	717	3261	3900	10289	32548	258
378	139	101-150	0	0		8968	10998	1196	17004	680353	11429	772	3985	10066
381	144	101-150		0		63	11205	122		84984	20648	225280	1486	75176
356	47	151-200		0		0	0	0	137	0	1337	12937	8046	2683
357	164	151-200	0	18097		0	0	0	606	16414	425145	163606	38796	114178
379	106	151-200	0	0	720	0	135	0	12511	70342	254080	7709	329867	116970
380	96	151-200		0		1024	9346	10240		1000960	698502	258603	120866	607392
721	65	201-300		0		0	0	0	2889	3282	1112	852	256	3054
723	155	201-300		0		0	16872	0	0	12667	92831	44044	3333	53799
725	105	201-300	14315	0		0	0	0	271	527	91803	1814540	748369	206794
727	96	201-300		0		13213	0	11429		28660	2119	98477	326841	62635
722	84	301-400		0		0	37	734	2890	60	156	0	36	0
724	124	301-400	0	0		0	0	0	0	55	628	58	165	53
726	72	301-400	0	0		0	0	0	0	7	54	2048	0	406
728	78	301-400		0		0	0	1671		7280	0	0	86	135
752	131	401-500		0		0	0	0		86	0	49	222	58
756	101	401-500		0		0	0	0	0	0	46	42	869	84
760	154	401-500		0		0	0	0	0	0	283	49	0	0
764	100	401-500		0		0	0	0	42	0	0	0	0	0
753	138	501-600		0		0	0	0		0	0	0	0	166
757	102	501-600		0		0	0	0		204	0	0	27	0
761	171	501-600		0		0	0	0	0	0	0	0	0	0
765	124	501-600		0		0	0	0	0	37	0	0	0	0
754	180	601-700				0	0	0		0	0	0	0	0
758	99	601-700				0	0	94		16302	0	19	88	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
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	2,043	1,618	2,654	1,627	1,274
Std. Error (tons)			13	17	1	17	36	9	72	814	716	1693	590	352

Table 3. Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 2003-2006 in NAFO Div. 3L.

Division 3L						
Stratum	Area miles^2	Depth range ft.	2003	2004	2005	2006
385	104	51-100	370	155		2190933
390	1481	51-100	1843	6868		4684608
389	821	101-150	23222674	67186990		86518447
391	282	101-150	1116135	1299793		3712072
387	718	151-200	49414721	60923347		84049080
388	361	151-200	25451607	25057182		32950165
392	145	151-200	2821419	1866379		193967
729	186	201-300	20371	1465049		88481
731	216	201-300	2449416	1467221		177357
733	468	201-300		8155		780103
730	170	301-400	0	876		1485
732	231	301-400	34907	5643		14535
734	228	301-400		608		15727
741	223	401-500	0	124		3076
745	348	401-500	17642	0		1699
748	159	401-500	292	696		366
742	206	501-600	0	0		1513
746	392	501-600	0	0		134
749	126	501-600	0	23		99
743	211	601-700		0		4220
747	724	601-700		0		147
750	556	601-700		0		58
744	280	701-800		0		783
751	229	701-800				0
Biomasa (ton.)			104,551	159,289		215,389
Std. Error (tons)			37,403	65,867		21,161

Table 4. Northern shrimp size distribution (‘000) by sex from Spanish bottom trawl survey 2006 in NAFO Div. 3NO an 3L.

3NO				3L			
OCL(mm)	**Males**	**Females**	**Total**	**OCL(mm)**	**Males**	**Females**	**Total**
9				9	28062		28062
9.5				9.5	28062		28062
10				10			0
10.5	27		27	10.5			0
11	116		116	11			0
11.5	238		238	11.5			0
12	1254	13	1267	12	10675		10675
12.5	2600	13	2614	12.5	7220		7220
13	4067		4067	13	8611		8611
13.5	3054		3054	13.5	37578		37578
14	4303		4303	14	114427		114427
14.5	2360		2360	14.5	163974		163974
15	3222		3222	15	417094		417094
15.5	2094		2094	15.5	529028		529028
16	5975	6	5981	16	327683		327683
16.5	4549	277	4827	16.5	264900	5	264906
17	6091	288	6379	17	787055		787055
17.5	8436	117	8553	17.5	1052316	27315	1079631
18	6956	267	7222	18	1401422	35672	1437095
18.5	9059	699	9758	18.5	1506372	41979	1548351
19	10477	580	11057	19	2216487	64865	2281353
19.5	10499	264	10762	19.5	2994151	42240	3036391
20	12364	879	13243	20	3059052	69856	3128908
20.5	8234	1752	9986	20.5	2575718	47528	2623246
21	6404	2482	8886	21	2671323	206413	2877735
21.5	4256	5988	10244	21.5	2244233	341187	2585420
22	2946	8079	11025	22	1493551	552610	2046161
22.5	1604	13285	14890	22.5	1224296	1045028	2269324
23	1134	14918	16052	23	614557	1373307	1987865
23.5	462	14786	15248	23.5	338355	1570836	1909192
24	110	11507	11617	24	76639	1704308	1780947
24.5		9293	9293	24.5	40725	1301823	1342549
25		7027	7027	25	5313	1029088	1034401
25.5		3706	3706	25.5		611451	611451
26		2677	2677	26		496924	496924
26.5		1289	1289	26.5		148205	148205
27		460	460	27		62777	62777
27.5		227	227	27.5		16639	18512
28		119	119	28		4828	4828
28.5		124	124	28.5		11712	11712
29				29		1776	1776
29.5				29.5		752	752
30				30		433	433
30.5				30.5			
31				31		23	23
31.5				31.5		23	23
Total	122889	101123	224012	Total	26240750	10809607	37050357
	55%	45%			71 %	29 %	

Table 5. Northern shrimp length-weight relationship by sex, maturity stage and all combined from Spanish bottom trawl survey 2006 in NAFO Div. 3NO and 3L

Division 3NO				
	a	b	R^2	N
Males	0.00157	2.69305	0.958	1495
Inmature females	0.00204	2.60462	0.781	747
Mature females	0.00117	2.77975	0.818	561
All combined	0.00169	2.66478	0.974	2803

Division 3L				
	a	b	R^2	N
Males	0.00191	2.60149	0.879	4140
Inmature females	0.00036	3.15066	0.842	89
Mature females	0.00106	2.80151	0.851	488
Ovigerous females	0.01187	2.06709	0.553	540
All combined	0.00106	2.80373	0.916	5256

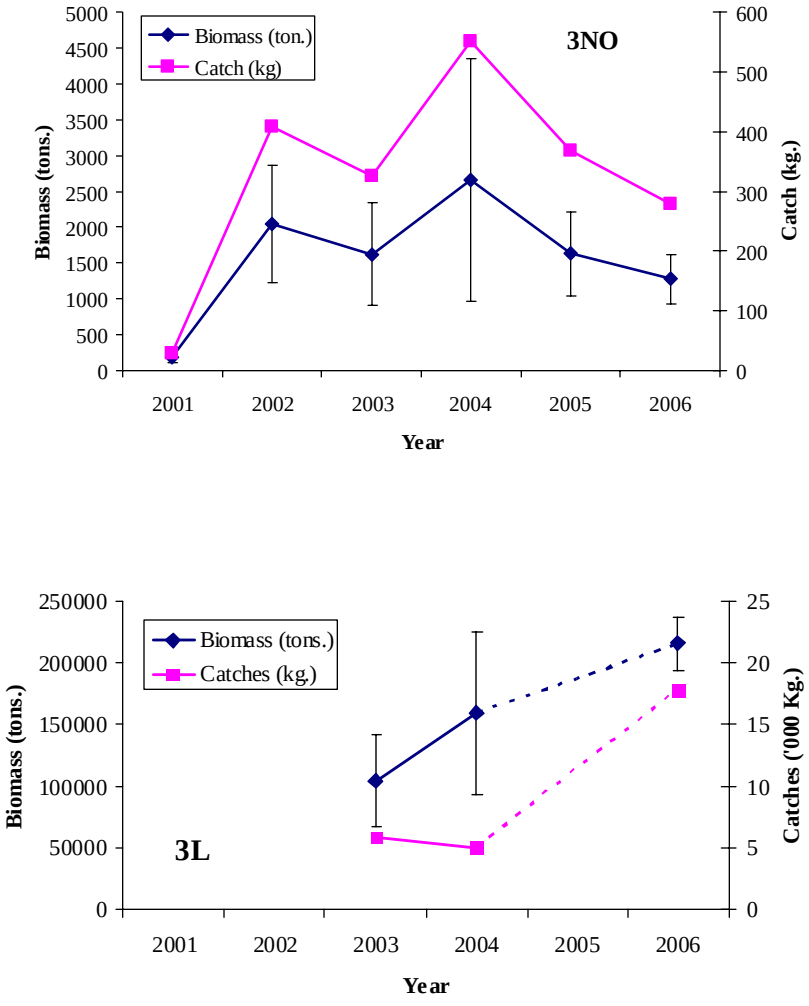

Fig. 1. Northern shrimp biomass (tons) and catch (kg) from Spanish research surveys in NAFO Div. 3NO 2001-2006 and 3L 2003-2006.

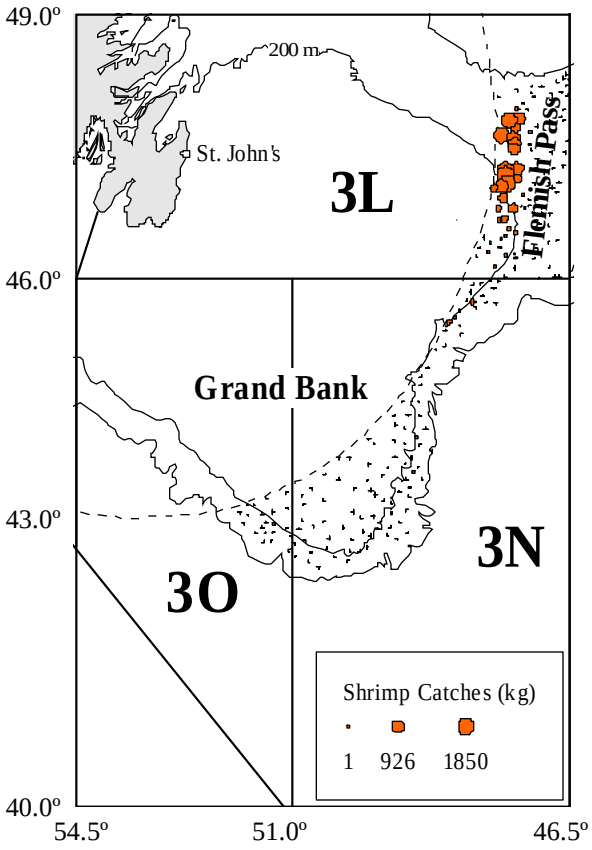

Fig. 2. Geographic distribution of Northern shrimp catches from Spanish bottom trawls surveys 2006.

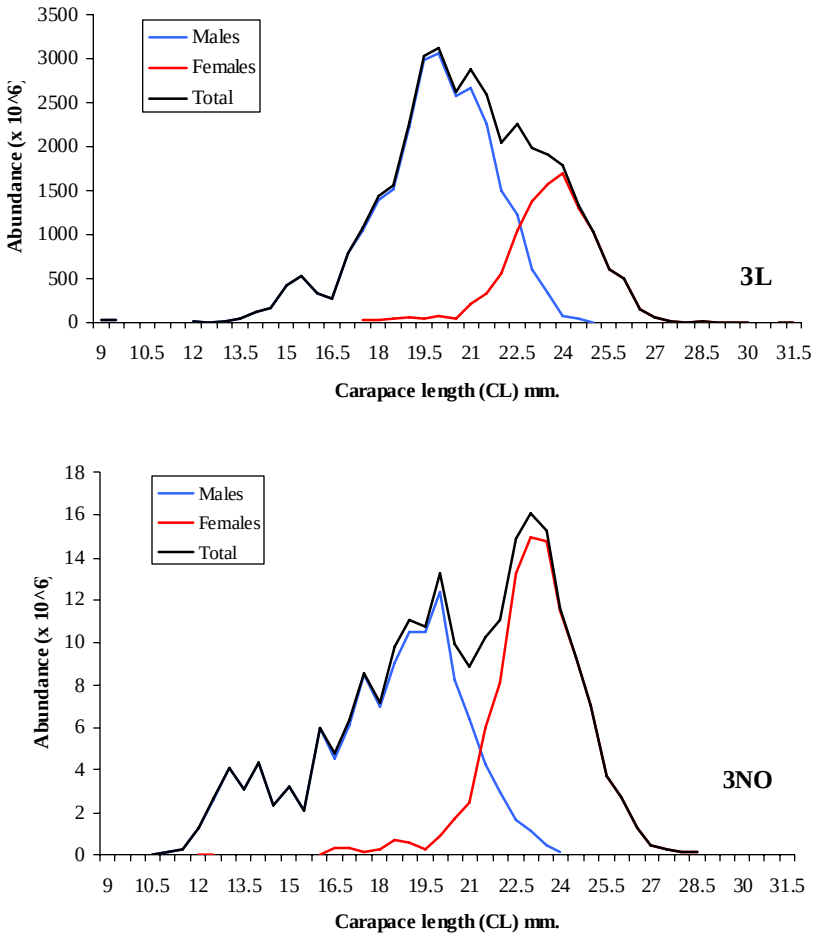

Fig. 3. Northern shrimp size distribution, by sex from Spanish bottom trawl surveys in Div. 3NO and 3L.