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Northern Shrimp (*Pandalus borealis*, Krøyer) from Spanish Bottom Trawl Survey 2008 in NAFO Div. 3LNO

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Abstract

The Spanish Institute of Oceanography carried out in 2008 two bottom trawl surveys in the NAFO Regulatory Area in Division 3NO and 3L during the months of June, July and August respectively. The results on Northern shrimp (*Pandalus borealis*) are presented and compared with those from previous surveys from the same series. In 2008 the catch (24.2 kg.) and estimated biomass (143.8 t.) confirm the decrease of shrimp importance from 2004 in 3NO. In 3L Division, northern shrimp indices show a general increasing trend a long the whole period. Estimated biomass increased from 2003-2006; then, the values of these indices declined in 2007 (about 10%) and increased again in 2008 (149 265 t.).

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 (Román *et al.*, 2008). 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 2008.

Materials and Methods

The 2008 Spanish bottom trawl surveys were carried out from the 27th of May to 16th of June in 3NO and from 24th 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 122 and 100 valid hauls respectively ranging depths between 40 and 1450 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 -CL- to the lower 0.5 mm length-classes (Shumway *et al*., 1985). Such measurements were made to the lower half millimetre using electronic callipers.

Furthermore, in 2008 survey some samples were frozen onboard to determine the length-weight relationship in the laboratory. 723 and 7160 individuals were selected in 3NO and 3L Divisions respectively, dried and weighed with a precision of 0.01g 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 1995-2008 in the NAFO Div. 3NO and from 2003-2008 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 four years both the catches and estimated biomasses of shrimp have decreased gradually to levels of biomass in 2008 around 144 t. (Figure 1).

Unlike 3NO, the estimated biomass in Division 3L since the beginning of the new survey in 2003 showed an increasing trend from 63 647 t. in 2003 to 149 265 t. in 2008.

The distribution of northern shrimp catches in the Spanish trawl survey 2008 is shown in Figure 2. As in previous years the main catches were located at medium depths (179-386 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 2008 surveys in Divisions 3NO and from 2003 to 2008 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 sex ratio was similar in both Divisions with a higher percentage of the males (65% and 68% respectively), the range of their length distribution was different, showing the 3L Division a broader range (8 to 31.5 mm.). Also both Divisions show important differences in their length distributions. While the 3NO Division shows a clear succession of modes along all length range (12.5, 16.5, 19.5 and 23 mm.) in 3L Division appears only well marked two modes at 19 and 21.5 mm. for males and one mode at 23 mm. for females.

The MIX modal size analysis programme was used with the length distributions estimated. From the cited analysis in 3NO Divisions the males presented three clear modes at 12.8, 16.6 and 20 mm. corresponding to ages 2, 3 and 4 respectively. The sex change occurs at age 4 and the females showed a unimodal distribution with a strong mode at 23.2 mm and another residual mode at 26.4 mm. corresponding to age group 5 and 6 years old respectively. The analysis from 3L Division showed in general a similar pattern in the location of the modal group but less clearly at 12, 16.9, 19.1 and 21.4 mm. for males and 21.1, 23.3 and 25.6 mm for females (Table 5) .

The Table 6 shows the length-weight relationship estimated in 2008 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 (t.), standard error and catches (kg.) from Spanish bottom trawl survey in NAFO Div. 3NO, 1995-2008 and 3L 2003-2008.

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	285	71
2008[2]	144	98	24

3L			
Year	Biomass		Catch
	tons	Std. err	(kg.)
2003	63 647	20 105	5 836
2004	94 270	40 332	5 093
2005		Not surveyed	
2006	125 850	12 690	17 805
2007	113 402	13 445	18 098
2008	149 265	48 489	23 720

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Table 2.- Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 2001-2008 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	2008
375	271	0-30	0	0		0	0	0	3453	0	25	0	0	1989	0	0
376	1334	0-30	0	0		0	0	0	1270	0	0	0	341	4203	0	0
353	269	31-50	0	0		0	0	0	79	0	48	0	0	0	126	0
360	2783	31-50	0	0		0	0	0	26423	1457	3470	24	0	0	445	0
374	214	31-50	0	0		0	0	0	178	0	0	0	0	0	62	0
354	246	51-100	0	0		0	0	0	87612	0	292	6917	0	0	14	0
359	421	51-100	0	0		0	1389	0	6348	847	1309	43	41	22	98	42
377	100	51-100	0	0		0	208	44	0	2020	751	1471	3742	3704	83	60
382	343	51-100		0		0	213	206		112695	302	297	825	944	191	4131
355	74	101-150		0		0	0	0	15170	147	7635	6146	6183	9179	262	204
358	225	101-150	0	0		0	30129	0	717	3261	3900	10289	32548	258	2357	2902
378	139	101-150	0	0		8968	10998	1196	17004	680353	11429	772	3985	10066	1357	481
381	144	101-150		0		63	11205	122		84984	20648	225280	1486	75176	303300	114294
356	47	151-200		0		0	0	0	137	0	1337	12937	8046	2683	213	635
357	164	151-200	0	18097		0	0	0	606	16414	425145	163606	38796	114178	9307	1249
379	106	151-200	0	0	720	0	135	0	12511	70342	254080	7709	329867	116970	12146	2238
380	96	151-200		0		1024	9346	10240		1000960	698502	258603	120866	607392	6488	11379
721	65	201-300		0		0	0	0	2889	3282	1112	852	256	3054	0	257
723	155	201-300		0		0	16872	0	0	12667	92831	44044	3333	53799	14615	90
725	105	201-300	14315	0		0	0	0	271	527	91803	1814540	748369	206794	47133	578
727	96	201-300		0		13213	0	11429		28660	2119	98477	326841	62635	1248	3172
722	84	301-400		0		0	37	734	2890	60	156	0	36	0	0	0
724	124	301-400	0	0		0	0	0	0	55	628	58	165	53	213	0
726	72	301-400	0	0		0	0	0	0	7	54	2048	0	406	170	0
728	78	301-400		0		0	0	1671		7280	0	0	86	135	0	0
752	131	401-500		0		0	0	0		86	0	49	222	58	309	0
756	101	401-500		0		0	0	0	0	0	46	42	869	84	27	84
760	154	401-500		0		0	0	0	0	0	283	49	0	0	590	0
764	100	401-500		0		0	0	0	42	0	0	0	0	0	0	0
753	138	501-600		0		0	0	0		0	0	0	0	166	0	0
757	102	501-600		0		0	0	0		204	0	0	27	0	67	0
761	171	501-600		0		0	0	0	0	0	0	0	0	0	99	0
765	124	501-600		0		0	0	0	0	37	0	0	0	0	0	0
754	180	601-700				0	0	0		0	0	0	0	0	0	207
758	99	601-700				0	0	94		16302	0	19	88	0	0	0
762	212	601-700				0	0	0	0	85	0	0	0	0		0
766	144	601-700				0	0	0		19	58	0	0	0		0
755	385	701-800				0	0	89		0	174	0	68	0	0	1839
759	127	701-800				0	0	0		17	0	48	0	0		0
763	261	701-800				0	0	0		0	0	0	0	0		0
767	158	701-800				0	0	0		0	0	0	0	0		0
Biomasa (ton.)			14	18	1	23	81	26	178	2043	1618	2654	1627	1274	401	144
Std. Error (tons)			13	17	1	17	36	9	72	814	716	1693	590	352	285	98
Biomass %		< 200 fth	0%	100%	100%	43%	79%	46%	97%	97%	88%	26%	34%	74%	84%	96%

Table 3.- Northern shrimp biomass (kg.) by strata from Spanish bottom trawl survey 2003-2008 in NAFO Div. 3L.

Division 3L								
Stratum	Area miles^2	Depth range ft.	2003	2004	2005	2006	2007	2008
385	2356	51-100	420	175		2485867	2416545	8265541
390	1481	51-100	1014	3780		2577958	5404325	317330
389	821	101-150	14397	41654		53639329	4912020	7440407
391	282	101-150	11161	12997		3712072	1239747	2494804
387	718	151-200	17618	21721		29967360	1178282	1428715
388	361	151-200	25169	24779		32585066	2695492	2160279
392	145	151-200	28214	18663		193967	1199955	3675300
729	186	201-300	20371	14650		88481	172095	16126
731	216	201-300	24494	14672		177357	666240	1501056
733	468	201-300		4077		390052	3281339	240647
730	170	301-400	0	876		1485	76	32
732	231	301-400	34907	5643		14535	4723	1905
734	228	301-400		408		10554	136	2144
741	223	401-500	0	56		1379	22	486
745	348	401-500	17642	0		1699	186	1950
748	159	401-500	292	696		366	499	66
742	206	501-600	0	0		462	0	0
746	392	501-600	0	0		134	0	74
749	126	501-600	0	23		99	0	0
743	211	601-700		0		1020	0	23
747	724	601-700		0		147	0	41
750	556	601-700		0		58	0	132
744	280	701-800		0		185	0	0
751	229	701-800				0	0	0
Biomasa (tons)			63647	94270		125850	113402	149265
Std. Error (tons)			20105	40332		12690	13445	48489
Biomass %		< 200 fth	96%	97%		99%	96%	99%

Table 4.- Northern shrimp size distribution (‘000) by sex from Spanish bottom trawl survey 2008 in NAFO Div. 3NO an 3L.

3NO			
CL (mm)	**Males**	**Females**	**Total**
8			
8.5			
9			
9.5			
10			
10.5	7	0	7
11	7	0	7
11.5	283	0	283
12	904	0	904
12.5	1105	0	1105
13	373	0	373
13.5	387	0	387
14	380	0	380
14.5	186	0	186
15	509	0	509
15.5	782	0	782
16	1244	0	1244
16.5	1246	0	1246
17	1036	0	1036
17.5	768	0	768
18	959	0	959
18.5	960	0	960
19	1250	0	1250
19.5	1630	15	1646
20	1156	14	1169
20.5	1117	104	1221
21	614	291	904
21.5	590	500	1090
22	334	1423	1757
22.5	114	1442	1556
23	0	1771	1771
23.5	0	1396	1396
24	16	1238	1253
24.5	0	760	760
25	0	300	300
25.5	0	126	126
26	0	144	144
26.5	0	29	29
27	0	20	20
27.5	0	90	90
28	0	13	13
28.5			
29			
29.5			
30			
30.5			
31			
31.5			
Total	17958	9676	27634
	65%	35%	

3L			
CL (mm)	**Males**	**Females**	**Total**
8	9		9
8.5			
9			
9.5			
10			
10.5			
11			
11.5	18		18
12	25494		25494
12.5	80		80
13	230		230
13.5	6759		6759
14	32990		32990
14.5	56933		56933
15	67028		67028
15.5	60126		60126
16	347018		347018
16.5	527962		527962
17	738474	215	738689
17.5	928701	1559	930260
18	1095305	12	1095317
18.5	1837990	3484	1841474
19	2160592	16554	2177146
19.5	1720048	122242	1842290
20	1709355	99493	1808848
20.5	1676261	134220	1810481
21	1673718	398332	2072051
21.5	1761902	465551	2227452
22	913607	693826	1607434
22.5	503834	961344	1465178
23	258084	1066668	1324752
23.5	117703	972755	1090458
24	42685	857745	900430
24.5	13838	758886	772724
25	20324	563488	583811
25.5		534221	534221
26		318211	318211
26.5		277508	277508
27		146070	146070
27.5		53758	53758
28		54594	54594
28.5		20013	20013
29		166	166
29.5		158	158
30		3395	3395
30.5		8	8
31			
31.5		79	79
Total	18297070	8524559	26821628
	68%	32%	

Table 5. Results of the modal analysis (MIX) by sex and maturity stage Spanish bottom trawl survey 2008 in NAFO Div. 3NO and 3L (out ZEE Canada).

Sex and maturity group	**Males**		**Females**	
Age	***Prop.***	***St. Dev.***	***Prop.***	***St. Dev.***
1				
2	0.002	0.000		
3	0.108	0.000		
4	0.456	0.000	0.089	0.000
5	0.434	0.000	0.622	0.000
6			0.288	0.000
7				
Age	***Mean CL***	***St. Dev.***	***Mean CL***	***St. Dev.***
1				
2	12	FIXED		
3	16.87	0.001		
4	19.12	0.001	21.07	0.003
5	21.39	0.001	23.28	0.001
6			25.61	0.001
7				
Age	***Sigma***	***St. Dev.***	***Sigma***	***St. Dev.***
1				
2	0.540	Fixed CV		
3	0.759	Fixed CV		
4	0.860	Fixed CV	0.948	Fixed CV
5	0.963	Fixed CV	1.047	Fixed CV
6			1.153	Fixed CV
7				

Table 6.- Northern shrimp length-weight relationships by sex, maturity stage and all combined in the calculation of biomass from Spanish bottom trawl survey 2008 in NAFO Div. 3NO and 3L (out ZEE Canada). The equation is $Weight=a(CL)^b$.

Sex group	Length-Weight Equations	No.	r^2
	3NO		
Males	$W = 0.00195\ CL^{2.61113}$	388	0.95710
Inmature females	$W = 0.00188\ CL^{2.62291}$	178	0.71161
Mature females	$W = 0.00232\ CL^{2.56037}$	156	0.67733
All combined	$W = 0.00189\ CL^{2.62251}$	723	0.96714
	3L		
Males	$W = 0.00157\ CL^{2.66009}$	5142	0.90098
Inmature females	$W = 0.00097\ CL^{2.83580}$	354	0.83400
Mature females	$W = 0.00133\ CL^{2.72181}$	1266	0.75893
Ovigerous females	$W = 0.00119\ CL^{2.78404}$	398	0.78802
All combined	$W = 0.00107\ CL^{2.79292}$	7160	0.94456

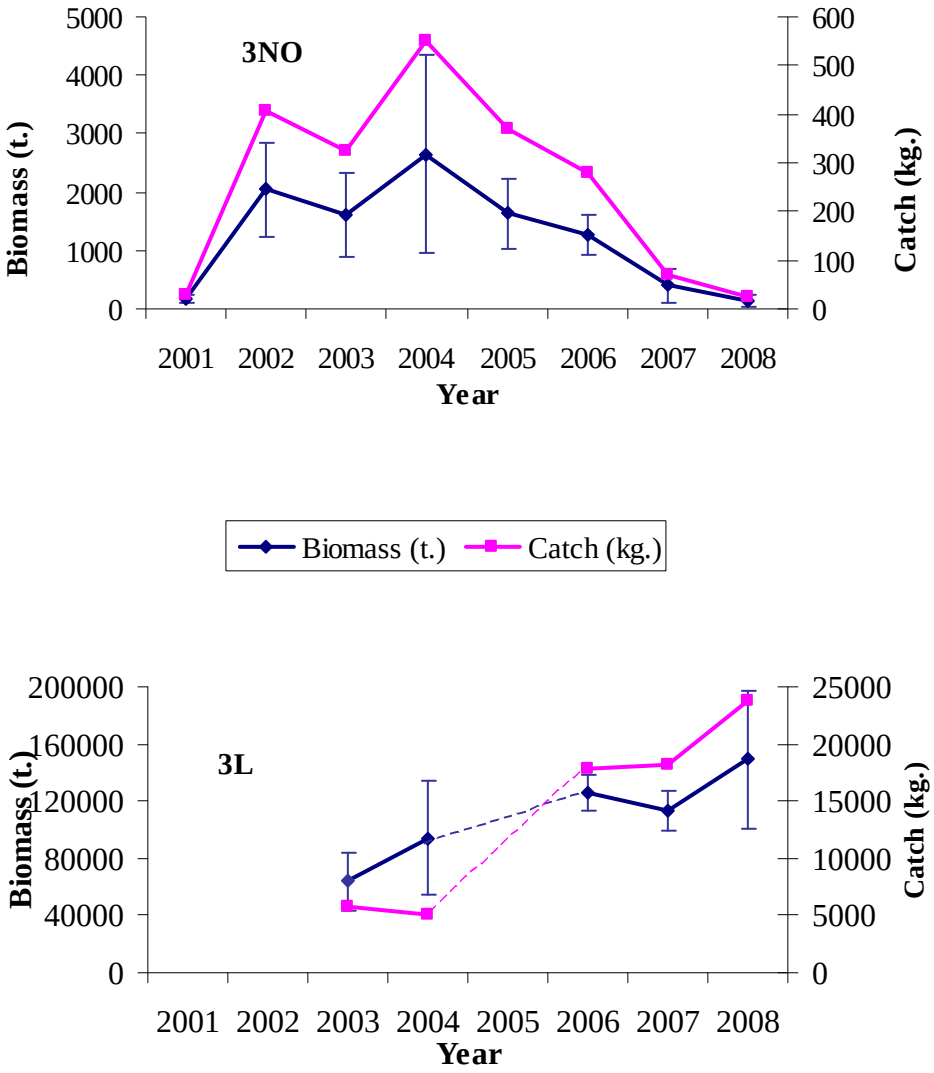

Figure 1.- Northern shrimp biomass (tons) and catch (kg) from Spanish research surveys in NAFO Div. 3NO 2001-2008 and 3L 2003-2008.

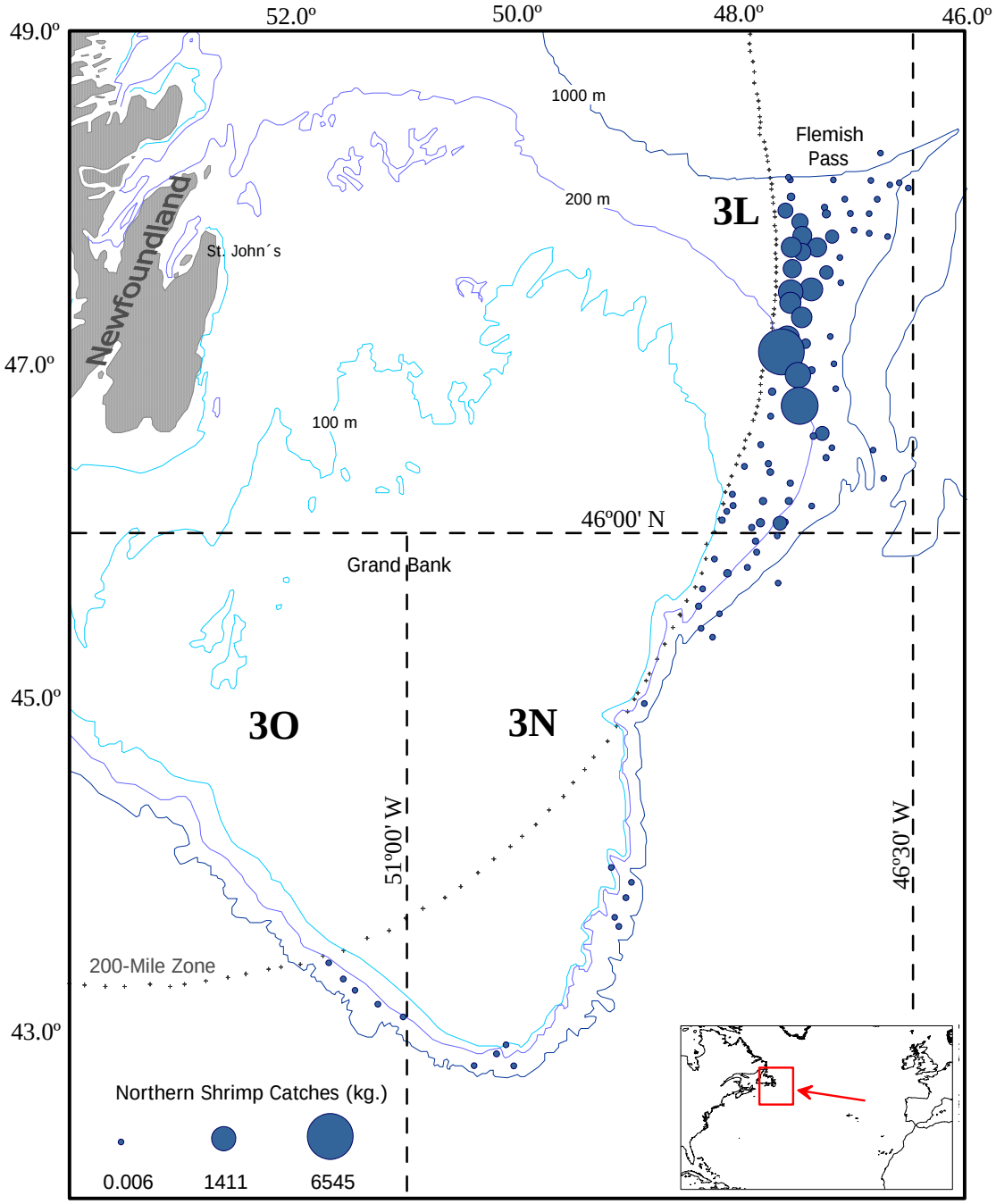

Figure 2.- Geographic distribution of Northern shrimp catches from Spanish bottom trawls surveys 2008.

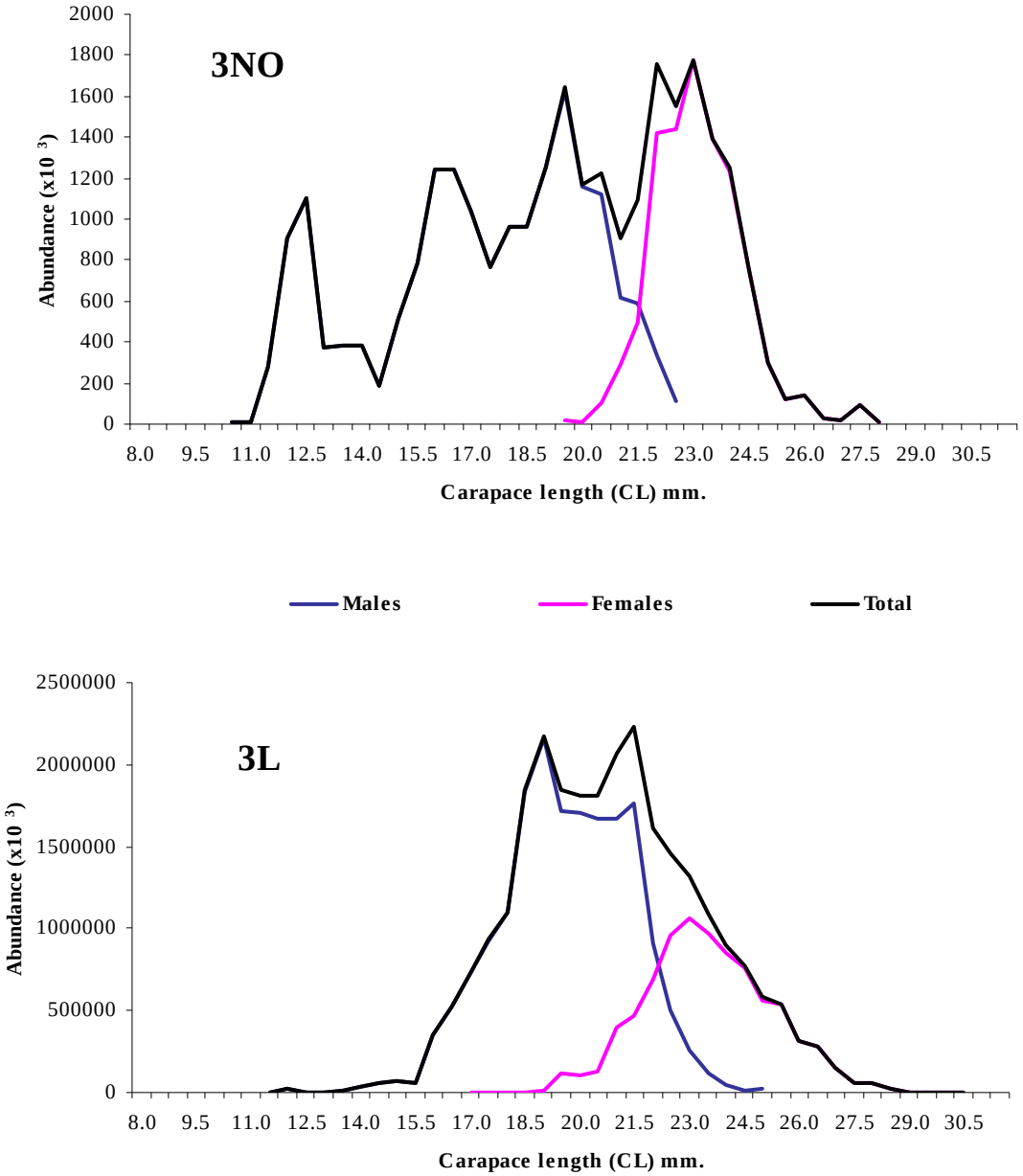

Figure 3.- Northern shrimp size distribution, by sex from Spanish bottom trawl surveys in Div. 3NO and 3L.