

## SEA ICE PREDICTION NETWORK (SIPN)

### Template for Pan-Arctic Sea Ice Outlook Core Contributions July Report

1. David Rennie / Amateur
2. Type of Outlook projection  
Heuristic

If you use a model, please specify:

Model Name: PIOMAS

Components of the model: Ice

For non-coupled model: Ice \_\_\_\_, Ocean \_\_\_\_, Forcing \_\_\_\_

Are you initializing your method with data from May (or earlier): April PIOMAS and NSIDC Sea Ice extent

3. September monthly average projection 3.2 M Sq Km
4. Short explanation of Outlook method (1-3 sentences)

The April PIOMAS figures show us, not only the highest monthly average volume of ice in the Arctic, but also the thickness distribution of that ice. The distribution over the past four years has varied considerably allowing the development of a model based on the varied quantity of ice at a specific starting thickness. The modal thickness of the arctic ice has dropped from 2.3m in 2012 to 1.8m in 2014.

5. Projection uncertainty/probability estimate 2.5 – 3.7 M sq Km

6. Short explanation/assessment of basis for the uncertainty estimate in #5

The average melt thickness over the past three years has varied from 2.00 to 2.35m. This projection assumes an average melt of 2.15 m with +- 0.1 m std. variation.

7. \* "Executive summary" about your Outlook contribution

July should see a loss of extent of around 1.7 M Km<sup>2</sup> by July 16<sup>th</sup> followed by a loss of over 2M km<sup>2</sup> from then until Aug 1<sup>st</sup> resulting in an end of month extent of below 5.8 M Km<sup>2</sup>.

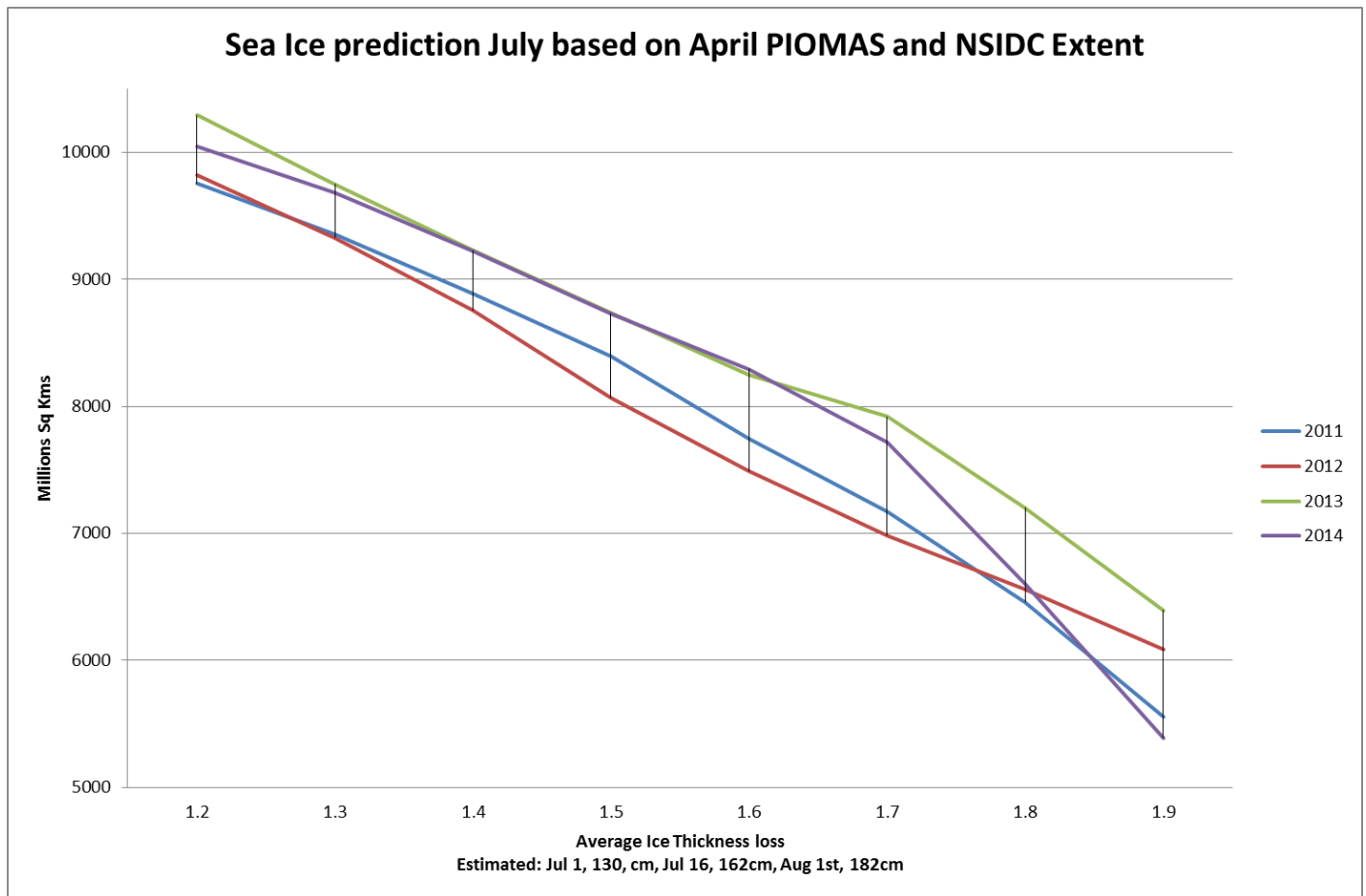
Starting with the April PIOMAS volume distribution and the April NSIDC average ice extent the estimated extent loss for each 10 cm thickness of ice loss is calculated. This calculation is then correlated with the reported 5 day average NSIDC ice extent loss. The calculation shows that the extent loss is closely correlated with the initial thickness distribution until the end of July. However the final September average figure is heavily dependent on August weather.

The minimum average thickness loss over the past three years is 2.00 meters. This year that melt would result in an extent of around 4.35 M km<sup>2</sup>. With 1.37 m of melt as of July 1<sup>st</sup>, a melt of only 2.00m seems highly unlikely.

Analysis

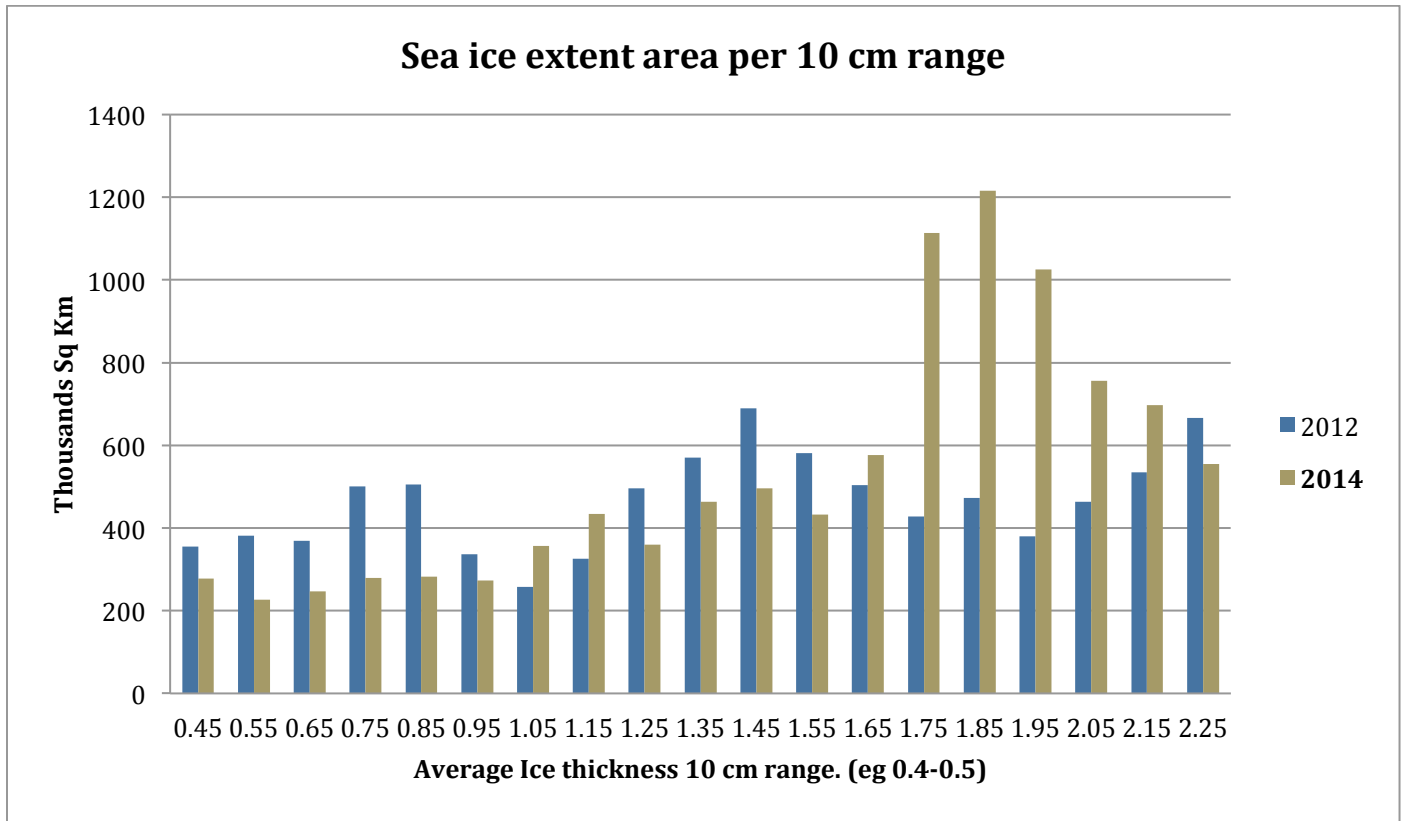
July Prediction

July commences with 2014 having 10 cm more melt than 2013 and 4 cm more than 2012. 2012 had significantly less melt than average in the first two weeks of July and it is possible that 2014 extent will drop below 2012 by mid-month. This would occur with 35cm of melt in the next two weeks which is approximately the melt in this period in 2011 and 2013. As can be seen from the graph below, once the melt reaches 1.7 m the loss in extent accelerates markedly.



The reason for this significant acceleration can be seen in the histogram below. Almost all thickness ranges up to 1.5 – 1.6 m contain considerably more ice and therefore extent in 2012 than in 2014. Above this the next 6 ranges show more than 2.3 M Sq km more extent in 2014 than in 2012. In each of the last three years the total melt for the season has been 2.00 or above. This amount of melt in 2014 will a take the extent down to 4.3 M km<sup>2</sup>.

It is possible to address the question of the final extent by considering the melt from July 1 to the end of the season. In the last 3 years, the melt after July 1 has been 73, 104 and 73 cm. A melt of 73 cm from July 1 would result in an overall melt of 2.1m. This would take the extent down to 3.6 Mkm<sup>2</sup> and in the range of a record. It would take 10cm less than this to prevent 2014 beating the 2007 figure. The current melt season does not suggest that such low values are likely and my estimate is that a record year is now 90% likely.

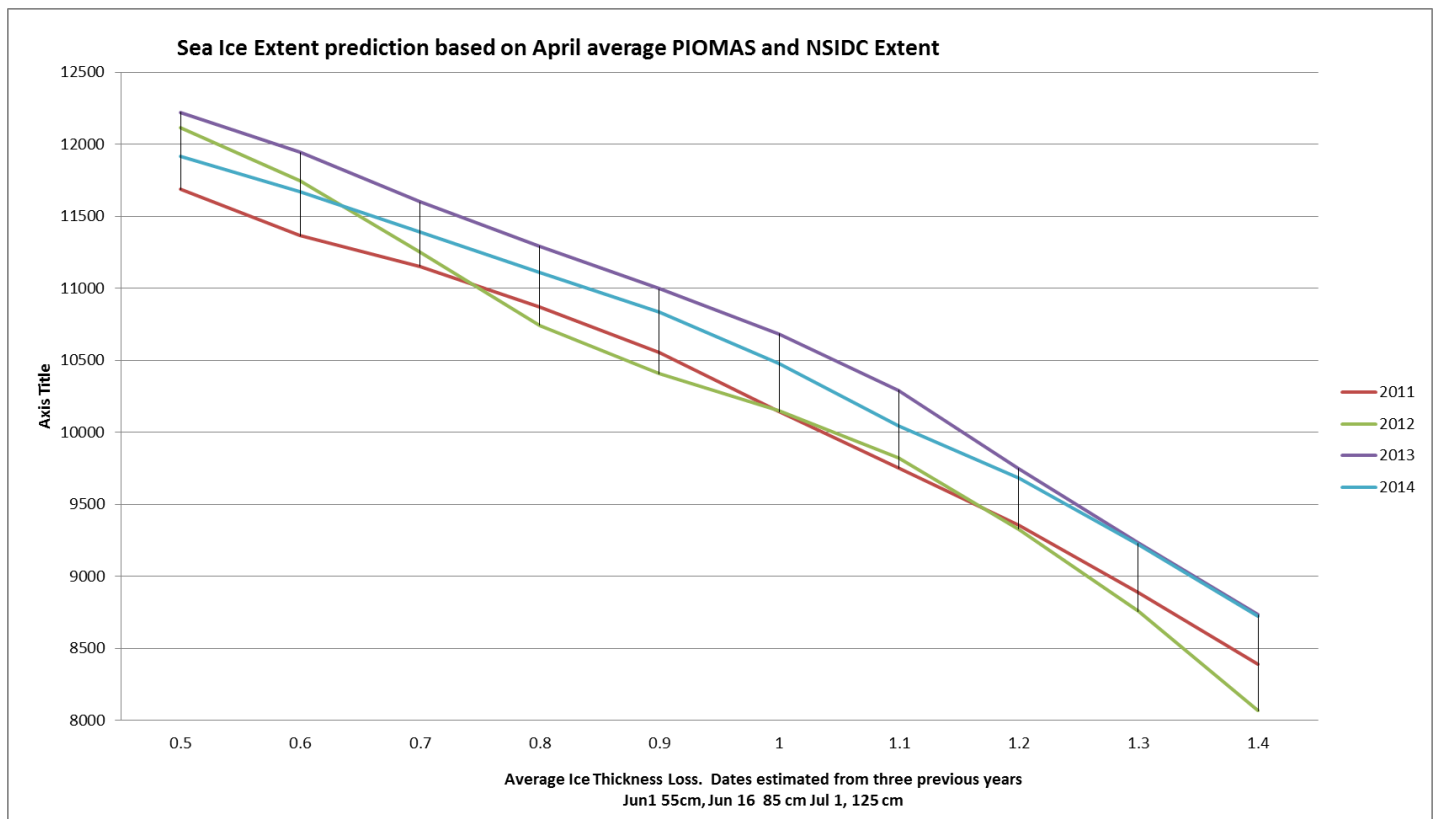


June in Review

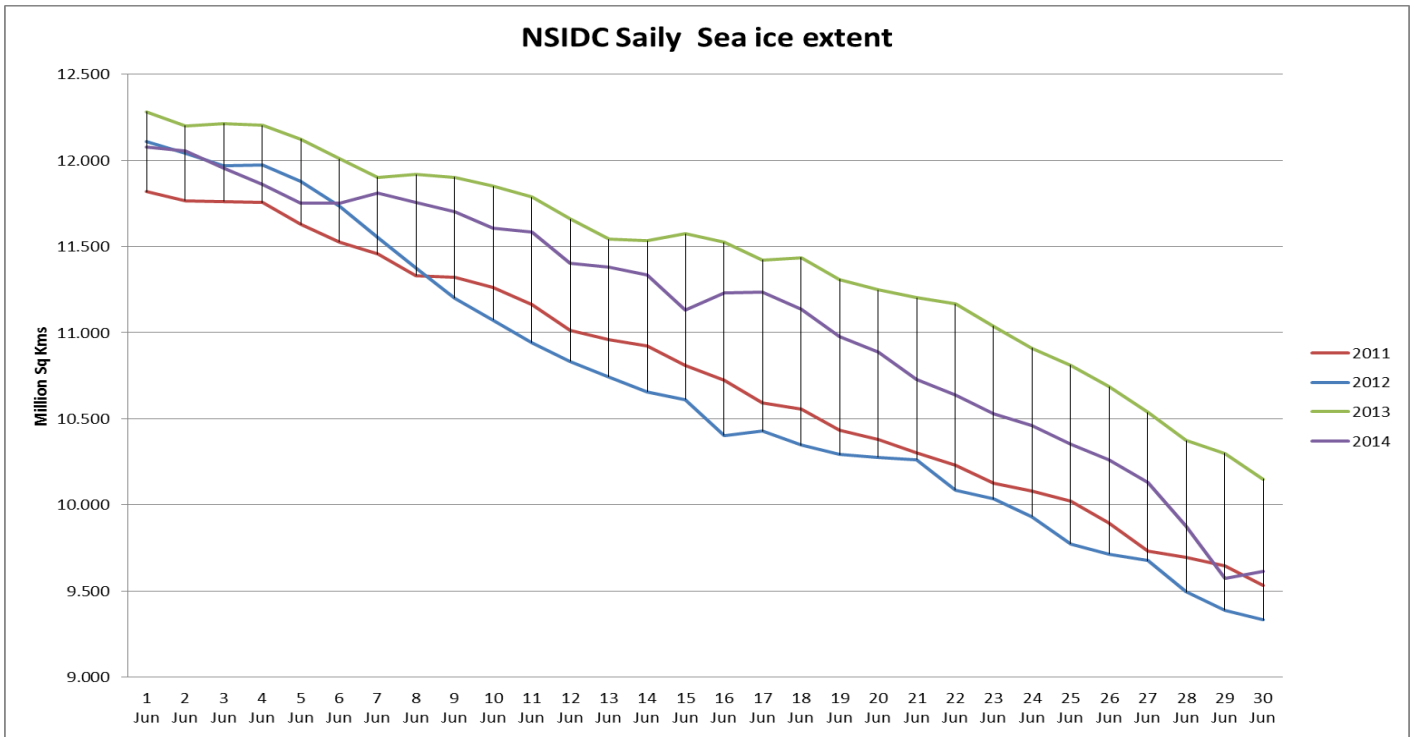
The estimate average thickness loss in June was 85 cm compared with 75 in 2011 and 2012 and 72 in 2013. The range in July varies from 47cm in 2011 to 55 cm in 2013. Assuming a 50 cm loss in 2014 the data suggests an extent of approximately 5.8 M Km at August 1.

	Average thickness loss since maximum				5 Day Average Extent			
	2011	2012	2013	2014	2011	2012	2013	2014
Jun 1st	0.55	0.58	0.56	0.52	11.874	12.176	12.335	12.109
Jun 16th	0.95	0.98	0.83	0.87	10.721	10.490	11.497	11.213
Jul 1st	1.30	1.33	1.27	1.37	9.359	9.141	9.901	9.406
Jul 16th	1.64	1.57	1.67		7.525	7.616	8.080	
Aug 1st	1.77	1.85	1.82		6.648	6.330	7.036	
Aug 15th	1.90	2.20	1.93		5.493	4.686	6.061	
Minimum	2.03	2.37	2.00		4.330	3.370	5.079	

The figures above suggest that the thickness loss in June is from approx. 55 cm to 130 cm producing a predicted extent loss displayed in the following graph.



The reported daily extent for June is displayed in the graph below. As can be seen both the crossover between 2011 and 2012, and 2012 and 2014 are quite accurately predicted by the model. The significant difference between the model and the actual is the rapid decline in 2014 in the last week in June which is not reflected in the model.

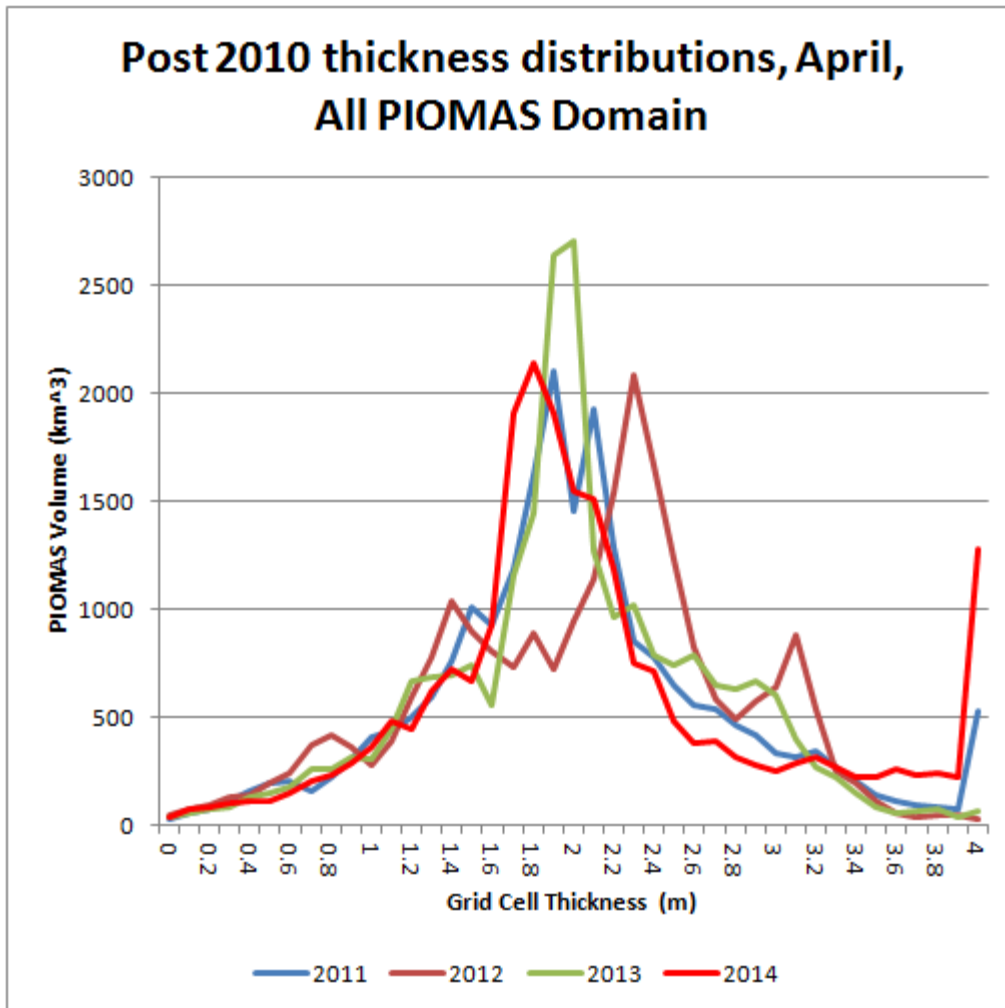


## June Prediction

The following graph provided by Chris Reynolds on the DOSBAT blog

(<http://dosbat.blogspot.com.au/2014/05/piomas-april-2014-gridded-data.html>)

provides the April thickness distribution of Arctic sea ice over the past four years.



Graph 1: PIOMAS thickness distribution of Arctic sea ice 2011 - 2014

Clearly the modal thickness has declined from 2.3 m in 2012, through 2m in 2013 to 1.8 m in 2014. However 2012 had significantly more ice in the range 0.5 to 0.9 m and 1.3m to 1.7m. From 0.9 to 1.2m 2012 has slightly less ice than the other years. These variations in volume should be reflected in extent loss throughout the melt season and should show up in the rate of decline during the season.

The first step of the analysis is to estimate the extent loss for each 10 cm of ice loss. The actual loss in 2011 to 2013 is then mapped against the estimated loss to determine when the estimated thickness loss occurred. This analysis is then used to predict the extent loss by the end of July and the final extent loss and confidence interval.

The ice volume and extent values estimated from Graph 1 are provided in the following table. (The estimates are very rough).

Thickness	Area / Km3	Estimated Volume from Graph				Estimated Area Represented			
		2011	2012	2013	2014	2011	2012	2013	2014
Metres		Km3	Km3	Km3	Km3	1000 Km2	1000 Km2	1000 Km2	1000 Km2
0.05	20000	30	30	30	30	600	600	600	600
0.15	6667	60	60	50	60	400	400	333	400
0.25	4000	90	90	70	90	360	360	280	360
0.35	2857	100	125	90	100	286	357	257	286
0.45	2222	160	160	140	125	356	356	311	278
0.55	1818	210	210	160	125	382	382	291	227
0.65	1538	210	240	180	160	323	369	277	246
0.75	1333	160	375	260	210	213	500	347	280
0.85	1176	240	430	260	240	282	506	306	282
0.95	1053	300	320	280	260	316	337	295	274
1.05	952	430	270	330	375	410	257	314	357
1.15	870	450	375	450	500	391	326	391	435
1.25	800	500	620	680	450	400	496	544	360
1.35	741	625	770	700	625	463	570	519	463
1.45	690	720	1000	720	720	497	690	497	497
1.55	645	1000	900	750	670	645	581	484	432
1.65	606	950	830	550	950	576	503	333	576
1.75	571	1250	750	1250	1950	714	429	714	1114
1.85	541	1670	875	1500	2250	903	473	811	1216
1.95	513	2000	740	2600	2000	1026	379	1333	1026
2.05	488	1450	950	2650	1550	707	463	1293	756
2.15	465	1950	1150	1150	1500	907	535	535	698
2.25	444	1350	1500	975	1250	600	667	433	556
2.35	426	850	2100	1000	750	362	894	426	319

Table 1: APRIL estimated volume and area of sea ice for each 10 cm of ice thickness.

The actual 5 day average extent as provided by NSIDC for selected dates through the season are shown here.

	5 Day Average Extent (Million sq km)			
	2011	2012	2013	2014
Jun-01	11.874	12.176	12.335	12.109
Jun-16	10.721	10.490	11.497	
Jul-01	9.359	9.141	9.901	
Jul-16	7.525	7.616	8.080	
Jul-31	6.648	6.330	7.036	
Aug-15	5.493	4.686	6.061	
Minimum	4.330	3.370	5.079	

Table 2: Actual 5 day average sea ice extent for selected dates.

The following table maps the actual extent as reported by NSIDC against the estimated volume loss from the PIOMAS data. The highlighted values illustrate the thickness range that the actual value fell into at that date. As an example, the June 16<sup>th</sup> figure was in the 0.80-0.90m range in 2013, but the 0.90 – 1.00m range for 2011 and 2012.

14071.95 14573.34 14295.25 14069.2

Thickness (Metre)	Cumulative Loss of Area for each Loss of Thickness 1000sq. km.				Estimated extent after thickness Loss 1000 sq. km.				
	2011	2012	2013	2014	2011	2012	2013	2014	
0.05	600	600	600	600	13472	13973	13695	13469	
0.15	1000	1000	933	1000	13072	13573	13362	13069	
0.25	1360	1360	1213	1360	12712	13213	13082	12709	
0.35	1646	1717	1470	1646	12426	12856	12825	12423	
0.45	2001	2073	1782	1923	12071	12501	12514	12146	
0.55	2383	2455	2072	2151	Jun-01	11689	12119	12223	11918
0.65	2706	2824	2349	2397		11366	11750	11946	11672
0.75	2919	3324	2696	2677		11152	11250	11599	11392
0.85	3202	3830	3002	2959	Jun-16	10870	10744	11293	11110
0.95	3518	4166	3297	3233		10554	10407	10999	10836
1.05	3927	4424	3611	3590		10145	10150	10684	10479
1.15	4318	4750	4002	4025		9753	9824	10293	10044
1.25	4718	5246	4546	4385	Jul-01	9353	9328	9749	9684
1.35	5181	5816	5065	4848		8891	8757	9230	9221
1.45	5678	6506	5561	5344		8394	8068	8734	8725
1.55	6323	7086	6045	5777		7749	7487	8250	8293
1.65	6899	7589	6379	6352	Jul-16	7173	6984	7917	7717
1.75	7613	8018	7093	7467		6459	6555	7202	6602
1.85	8516	8491	7904	8683	Jul-31	5556	6082	6392	5386
1.95	9542	8870	9237	9709	Aug-15	4530	5703	5058	4361
2.05	10249	9334	10530	10465		3823	5239	3766	3605
2.15	11156	9869	11065	11162		2916	4705	3231	2907
2.25	11756	10535	11498	11718		2316	4038	2797	2351
2.35	12118	11429	11923	12037	Minimum	1954	3144	2372	2032

Table 3: NSIDC 5 day average extent mapped against estimated extent from thickness loss.

### Observations and Predictions until July 31, 2014

We can see that the loss of thickness is remarkable consistent across the three years.

- by June 1<sup>st</sup> between 0.5 and 0.6 m of ice was lost in each year.
- by June 16<sup>th</sup> between 0.8 and 1.0 m was lost
- by July 1<sup>st</sup> between 1.2 and 1.4 m was lost
- by July 16<sup>th</sup> between 1.5 and 1.7m was lost
- by July 31 between 1.7 and 1.9 m was lost, with both 2012 and 2013 falling into the 1.8 – 1.9 m range.

Over this period none of the three years was always present in the set of years with the most thickness loss to that date. This suggests that over the period April – July the impacts of weather on the overall melt were balanced out over time.

Based on these figures I predict that in 2013.



1. The decline in extent from Jun 1 to Jun 16 will be approx. 500K sq. kms. less than 2012 and that the value will be similar to 2013.
2. The decline in extent will approximate that in 2013 until mid-July' when it will be about 750K sq. kms. above the figures for 2011 and 2012.
3. The decline in extent will increase dramatically after mid-July dropping below the 2012 figure by about 500K sq. kms. by Aug 1<sup>st</sup>.

### Observations and Predictions for 2014 melt season from Aug 1<sup>st</sup>

Despite the consistency of thickness loss prior to July 31<sup>st</sup>, loss after July 31<sup>st</sup> has varied widely, in 2011 the loss was approximately 30cm, in 2012 50 cm and in 2013 only 10cm. This appears to be highly dependent on the weather.

Not knowing the weather in August I have used a mid-range estimate of an average 30 cm loss after Aug 1st with a range of 20-40 cm. Based on the loss projected from the thickness distribution this suggests a final minimum around 3.2M sq. km. with a range between 2.5 and 3.8 M sq. km.

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