Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat
Central and Arctic Region | Science Response 2018/012

UPDATE OF STOCK STATUS INDICATORS FOR NORTHERN SHRIMP, *PANDALUS BOREALIS,* AND STRIPED SHRIMP, *PANDALUS MONTAGUI,* IN THE WESTERN AND EASTERN ASSESSMENT ZONES, FEBRUARY 2018

Context

Fisheries and Oceans Canada (DFO) Resource Management has requested an update on the stock status of the two species of shrimp, Northern Shrimp (*Pandalus borealis*) and Striped Shrimp
(*P. montagui*), in the Western Assessment Zone (WAZ) and Eastern Assessment Zone (EAZ). The last Zonal Peer Review (ZPR) for the WAZ and EAZ, which fully assessed the stock status, took place in February 2017 (DFO 2017). The full assessments and the updates follow the framework developed in 2007 for Northern Shrimp off Labrador and the northeastern coast of Newfoundland (DFO 2007a). The basis of this update is a series of previously reported fishery-independent surveys and fishery data, and new survey and catch data from the 2017/18 fishing season.

This Science Response Report results from the Science Response Process (SRP) of February 2, 2018 for the Northern and Striped Shrimp Update for the Eastern and Western Assessment Zones, and Striped Shrimp Update for Shrimp Fishing Area (SFA) 4.

Background

The EAZ and WAZ (Figure 1) were adopted in 2011 as the basis for assessing the status of shrimp in Shrimp Fishing Area (SFA) 2 and SFA 3 (DFO 2011). The combined boundary of the EAZ and WAZ is equivalent to the combined areas of SFAs 2 and 3 (subsequently redefined as SFAs Davis Strait, Nunavut and Nunavik) and their corresponding Management Units (Figure 1) implemented in the 2013/14 fishing season.

Two exploitation rates are presented for each assessment zone and species because the total allowable catch (TAC) is not generally taken. Exploitation rate refers to the realized rate based on reported catch, while the potential rate assumes the TAC had been fully taken.

In the EAZ, the first two years of survey data (2006–2007) are not considered comparable with the rest of the time series because of poor trawl performance and incomplete sampling coverage in the Resolution Island survey area. These years are not considered when assessing trends in the indices from the EAZ.

In 2014, the Central and Arctic Region reorganized the surveys conducted within the region. For shrimp, DFO stopped conducting the WAZ survey; since then, the area has been surveyed during the joint Northern Shrimp Research Foundation survey so that the WAZ, EAZ and SFA 4 (NAFO 2G) survey areas are all sampled with the same ship, gear and at the same time of year. While this resulted in restarting the time series in the WAZ, the future benefits to the assessment of shrimp outweighs this shortcoming. It should be noted that while all historical data are presented in this report, the two surveys are not directly comparable, as the surveys for the two zones were conducted with different ships, gear and at a different time of the year.

Resource status in the EAZ was evaluated within a Precautionary Approach (PA) framework (DFO 2006). Reference points (RP) were based on the geometric mean of female spawning stock biomass (SSB) during a seemingly productive time period. The Limit Reference Point (LRP) is 30% of the mean and the Upper Stock Reference (USR) is 80% of the mean. RPs for SFA 2 were developed based on estimates from available surveys (2006–2008) at that time (DFO 2009) and implemented in the Integrated Fisheries Management Plan (IFMP; DFO 2007b). These RPs were subsequently used in the EAZ when stock areas changed. RPs for the WAZ were developed in 2013 (DFO 2013); however, the restart of the time series means these RPs are no longer valid and as a consequence no PA framework is currently available for the WAZ.

Buffered random sampling was applied to allocation of sampling stations within the depth strata (Kingsley et al. 2004).

Upper and lower confidence intervals used in biomass and exploitation rate calculations, were estimated by resampling statistics (bootstrapping; Bruce et al. 2000).

Analysis and Response

Update of Indicators

Eastern Assessment Zone – *P. borealis*

Fishery

The total catch of *P. borealis* in the EAZ reported in Canadian Atlantic Quota Report (CAQR), as of 23 January 2018, was 6,087 t, which is 64% of the TAC (Table 1, Figure 2). The 2017/18 fishery runs until 31 March 2018, and with vessels still fishing the area, catch records should be considered preliminary for 2017/18.

Biomass

The fishable biomass index decreased by 40% from 2016 to 2017 and is now at the lowest level (39,198 t) since the time series began (Table 2, Figure 3a). The female SSB index showed a decrease of 29% and also is at the lowest level (24,800 t) (Table 2, Figure 3b).

Exploitation

The reported exploitation rate (ER) index for 2017/18, as of 23 January 2018, was 15.5% (Figure 4a). Since the fishery was still open at the time of the meeting, the reported ER may be higher at the end of the season. Should the entire TAC be taken this fishing season, the potential ER index for 2017/18 would be 24.2% (Figure 4b). The long term average of the potential ER is 14.3%, which is near the 15% harvest rate goal for the EAZ.

Current Outlook

Even though the stock biomass decreased in 2017, the female SSB index for *P. borealis* in the EAZ is currently within the Healthy Zone of the PA Framework (Figure 5).

Eastern Assessment Zone – *P. montagui*

Fishery

The total catch of *P. montagui* in the EAZ, as of 23 January 2018, was about 209 t (Table 1, Figure 6) and has been declining since 2001. The 2017/18 fishery runs until 31 March 2018, and with vessels still fishing the area, catch records are preliminary for 2017/18.

Biomass

Biomass indices for *P. montagui* in the EAZ oscillated around the long term mean, with the exception of a particularly high biomass reported in 2012 (Figure 7). Both the fishable biomass and the female SSB indices increased in 2017, and were well above the long term mean, with 24,957 t and 16,567 t, respectively (Table 3, Figure 7).

Exploitation

The reported ER index for 2017/18 was very low, 0.8%, due to low catches reported in the CAQR as of 23 January 2018 (Figure 8). The potential ER index for this stock would be 3.4% if the entire TAC is taken.

Current Outlook

As a consequence of the latest biomass increase, the female SSB index in the EAZ has shifted further into the Healthy Zone in the current year (Figure 9). Given the wide fluctuations in biomass indices for *P. montagui* observed in the past (e.g., between years 2011, 2012 and 2013) the status of this resource is considered uncertain.

Western Assessment Zone – *P. borealis*

While all survey years are presented, only the last four years of survey data can be considered in the WAZ assessment because of the change in the surveys, resulting in a re-start of the time series.

Fishery

As of 23 January 2018, the CAQR records show that about 424 t, which equals to 20% of the TAC, have been taken (Table 1, Figure 10). Considering the time left in the fishing season, it is unlikely that the TAC will be taken.

Biomass

The fishable biomass and female SSB indices from 2016 to 2017 decreased by 20% and 35%, respectively (Table 4, Figure 11). The fishable biomass index in 2017 was 10,487 t, while the female SSB index was 5,216 t.

Exploitation

The reported ER index for 2017/18 was relatively low, 4%, due to low catches reported in the CAQR as of 23 January 2018 (Figure 12a). As a consequence of the decline in the fishable biomass in 2017, the potential ER index has increased to about 20% (Figure 12b).

Current Outlook

Currently, there is no PA framework for this resource because the survey time series is too short for the stock at this time. At least one additional year of survey results will be required before reliable reference points can be established. An observed decrease in the biomass, and the increase in the potential ER are concerning. Historical records show that the TAC for this stock has rarely been fully taken.

Western Assessment Zone – *P. montagui*

While all survey years are presented, only the last four years of survey data can be considered in the WAZ assessment because of the change in the surveys, resulting in a re-start of the time series.

Fishery

The total catch of *P. montagui* was 5,194 t, which is 85% of the TAC as per 23 January 2018 CAQR (Table 1, Figure13). The 2017/18 fishery runs until 31 March 2018, and with vessels still fishing the area, catch records should be considered preliminary for the 2017/18 season.

Biomass

The fishable biomass index increased by about 42% from 2016 to 2017, with 44,915 t observed in 2017 (Table 5, Figure 14a). An even more pronounced biomass increase (62%) was observed for the female SSB index, with 30,305 t estimated.

Exploitation

Along with increasing fishable biomass, the reported ER index in 2017/18 decreased to 11.5% (Figure 15a). If the entire TAC was taken the potential ER index would be 13.7% (Figure15b).

Current Outlook

Currently, there is no PA framework for this resource because survey time series is too short for the stock at this time. At least one additional year of survey results will be required before reliable reference points can be established. Given the observed biomass increase started from a low level, which followed two years of decline, caution is recommended when considering an increase of the TAC.

Conclusions

Eastern Assessment Zone (EAZ)

Pandalus borealis

- Currently, the *Pandalus borealis* resource is in the Healthy Zone of the Precautionary Approach Framework.
- In 2017, the fishable biomass and female spawning stock biomass indices recorded large declines and both are at the lowest level since the time series began.
- The potential Exploitation Rate (ER) index for 2017/18 is 24.2%. That is well above both the long term mean of the potential ER (14.3%) and the 15% harvest rate goal for the EAZ.

Pandalus montagui

- *Pandalus montagui* biomass indices have fluctuated widely in the past, adding to the uncertainty about the status of the stock in the EAZ.
- Following this year's increase in the biomass, the *Pandalus montagui* resource is currently in the Healthy Zone of the Precautionary Approach Framework.
- The potential exploitation rate index if the TAC is taken in 2017/18 would be 3.4%.

Western Assessment Zone (WAZ)

Pandalus borealis

- The status of the stock is currently uncertain, as there is no Precautionary Approach Framework for *Pandalus borealis* in the WAZ.

- Both the fishable biomass and female spawning stock biomass indices recorded declines and are at the lowest levels of the time series.
- The reported exploitation rate index for 2017/18 is about 4%. The current TAC equates to a potential exploitation rate index of about 20%. Historical records show that the entire TAC for this stock has rarely been taken.

Pandalus montagui

- The status of the stock is currently uncertain, as there is no Precautionary Approach Framework for *Pandalus montagui* in the WAZ.
- Both the fishable biomass and female spawning stock biomass indices increased from 2016 to 2017.
- The reported exploitation rate index for 2017/18 is 11.5%; the potential exploitation rate index for 2017/18 is 13.7%.

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Appendix 1. Tables

Table 1. Nominal reported catches for the Eastern Assessment Zone and Western Assessment Zone for Pandalus borealis *and* P. montagui*.*

Year	Eastern Assessment Zone		Western Assessment Zone	
	P. borealis	***P. montagui***	***P. borealis***	***P. montagui***
2017*	6087.45	208.83	423.69	5194.21
2016	6666.83	357.82	642.74	5660.25
2015	4815.50	59.25	353.13	4616.37
2014	4972.11	401.16	846.72	5835.69
2013	6793.47	1075.29	973.28	4775.29
2012	5555.00	1172.72	13.00	1105.41
2011	7687.10	134.81	0	857.32
2010	6908.17	483.34	56.88	345.04
2009	5158.56	563.61	0	0
2008	5184.27	807.57	0	0
2007	6358.59	1832.29	0	0
2006	6027.55	924.73	0	0
2005	6386.84	1426.71	-	0
2004	5841.75	2301.35	-	0
2003	5617.44	1217.11	-	0
2002	5695.33	3080.80	-	0
2001	6275.38	3866.87	-	0
2000	5718.48	4238.49	-	0
1999	5465.10	3780.39	-	0
1998	5372.24	3359.89	-	0
1997	5869.76	3049.94	-	0
1996	3345.57	3058.24	-	0
1995	2488.59	3192.23	-	0
1994	455.81	154.05	-	0
1993	68.24	0	-	0
1992	1210.10	0.74	-	0
1991	1150.25	622.54	-	0.2
1990	1633.76	174.35	-	4.67
1989	3132.73	1264.81	-	9.55
1988	2873.42	602.91	-	13.00
1987	0.01	0.12	-	0

Table 1. continued

Year	Eastern Assessment Zone		Western Assessment Zone	
	P. borealis	***P. montagui***	***P. borealis***	***P. montagui***
1986	49.58	483.17	-	0
1985	0.08	0	-	0
1984	0	0	-	0
1983	21.135	0	-	0
1982	46.49	0	-	0
1981	0.891	9.111	-	2
1980	486.83	102.812	-	2.86
1979	0.625	58.347	-	25.38

** Catch based on CAQR as of 23 January 2018. Since the fishery is still open the catch is preliminary for 2018.*

Table 2. Fishable and female spawning stock biomass estimates for Pandalus borealis *in the Eastern Assessment Zone for the 2006-2017 surveys. Lower Control Level (LCL) and Upper Control Level (UPL) are the lower and upper 95% confidence limits. Year over year (YOY) change indicates the relative change in comparison to the previous year.*

Year	Biomass	YOY change (%)	Weight (tonne)		
			Mean	LCL	UCL
2017	Fishable	-40.2	39198.09	30225	48907
2016	Fishable	-17.0	65569.87	42137	93569
2015	Fishable	56.5	78984.09	50852	106962
2014	Fishable	1.5	50457.99	38914	62340
2013	Fishable	-17.9	49696.90	38427	60631
2012	Fishable	-22.9	60533.67	43074	79960
2011	Fishable	10.5	78530.23	23900	135037
2010	Fishable	-9.8	71064.51	40234	108703
2009	Fishable	54.3	78754.88	48850	110115
2008	Fishable	17.9	51053.43	37117	66708
2007	Fishable	32.0	43305.97	31015	58346
2006	Fishable	-	32815.89	21969	44152
2017	Female SS	-28.8	24799.79	19888	30252
2016	Female SS	-42.8	34827.08	24220	46979
2015	Female SS	78.7	60869.47	33379	88386
2014	Female SS	6.3	34069.42	25157	43000
2013	Female SS	-22.2	32049.10	26762	37607
2012	Female SS	-13.8	41189.85	29498	54383
2011	Female SS	9.1	47806.80	13470	82926
2010	Female SS	12.7	43800.31	19025	79665
2009	Female SS	40.5	38856.32	23122	56820
2008	Female SS	-0.2	27653.12	22507	39368
2007	Female SS	64.8	27698.44	19249	39007
2006	Female SS	-	16805.06	10523	23026

Table 3. Fishable and female spawning stock biomass estimates for Pandalus montagui *in the Eastern Assessment Zone for the 2006-2017 surveys. LCL and UCL are the lower and upper 95% confidence limits. Year over year (YOY) change indicates the relative change in comparison to the previous year.*

Year	Biomass	YOY change (%)	Weight (tonne)		
			Mean	LCL	UCL
2017	Fishable	81.0	24957.23	17246	32311
2016	Fishable	124.7	13791.57	6452	21126
2015	Fishable	-63.0	6136.90	3445	8629
2014	Fishable	371.0	16599.97	11203	22084
2013	Fishable	-87.8	3524.28	1738	6208
2012	Fishable	272.7	28845.47	8582	48946
2011	Fishable	4.3	7739.99	2871	14285
2010	Fishable	-52.7	7422.75	5714	9290
2009	Fishable	6.9	15679.12	6190	29774
2008	Fishable	203.8	14667.04	7287	21973
2007	Fishable	81.0	4828.25	3389	6673
2006	Fishable	-	2667.14	210	5122
2017	Female SS	64.4	16536.87	9866	23250
2016	Female SS	159.4	10056.16	2986	17280
2015	Female SS	-69.5	3876.62	2085	5452
2014	Female SS	357.1	12696.30	8834	16622
2013	Female SS	-88.2	2777.54	1301	4949
2012	Female SS	653.8	23552.02	6218	40985
2011	Female SS	-46.3	3124.24	1599	4721
2010	Female SS	-33.7	5819.1	4509	7136
2009	Female SS	-17.7	8775.54	4205	13955
2008	Female SS	440.9	10659.82	4269	17047
2007	Female SS	-7.7	1970.63	903	3490
2006	Female SS	-	2134.38	50	4219

Table 4. Fishable and female spawning stock biomass estimates for Pandalus borealis *in the Western Assessment Zone. Year over year (YOY) change indicates the relative change in comparison to the previous year. Note 2014 represents a start of the new time series and values are not directly comparable to previous years. LCL and UCL are the lower and upper 95% confidence limits.*

Year	Biomass	YOY change (%)	Weight (tonnes)		
			Mean	LCL	UCL
2017	Fishable	-20.0	10486.91	5073	17185
2016	Fishable	-54.0	13116.23	7867	18868
2015	Fishable	31.4	28532.16	18531	39501
2014	Fishable	-1.3	21712.50	14353	31046
2013	Fishable	11.7	21998.56	15906	28518
2011	Fishable	26.7	19692.10	12468	27961
2009	Fishable	6.4	15543.95	7613	25529
2007	Fishable	-	14614.98	4907	28872
2017	Female SS	-34.9	5216.15	3045	7676
2016	Female SS	-45.5	8014.94	4780	11590
2015	Female SS	19.5	14710.39	9270	20379
2014	Female SS	25.8	12308.93	8792	16398
2013	Female SS	53.5	9785.03	7106	12829
2011	Female SS	66.1	6376.60	4182	8909
2009	Female SS	18.8	3839.38	1154	7479
2007	Female SS	-	3231.03	1687	5361

Table 5. Fishable and female spawning stock biomass estimates for Pandalus montagui *in the Western Assessment Zone. Year over year (YOY) change indicates the relative change in comparison to the previous year. Note 2014 represents a start of the new time series and values are not directly comparable to previous years. LCL and UCL are the lower and upper 95% confidence limits.*

Year	Biomass	YOY change (%)	Weight (tonnes)		
			Mean	LCL	UCL
2017	Fishable	41.6	44915.31	29179	63381
2016	Fishable	-42.5	31724.17	19507	44908
2015	Fishable	-28.4	55194.40	35769	76429
2014	Fishable	68.9	77077.74	44854	111562
2013	Fishable	-36.2	45647.22	32899	59438
2011	Fishable	53.3	71557.90	40264	108612
2009	Fishable	-13.6	46672.87	25756	73342
2007	Fishable	-	54044.48	17007	99461
2017	Female SS	62.1	30305.24	18830	43434
2016	Female SS	-31.6	18690.62	11090	27334
2015	Female SS	-29.7	27323.60	18282	37041
2014	Female SS	44.2	38875.39	23553	55849
2013	Female SS	-17.2	26955.19	18616	35736
2011	Female SS	80.8	32549.40	20296	46119
2009	Female SS	-6.6	17998.70	9775	28160
2007	Female SS	-	19277.30	5668	36606

Appendix 2. Figures

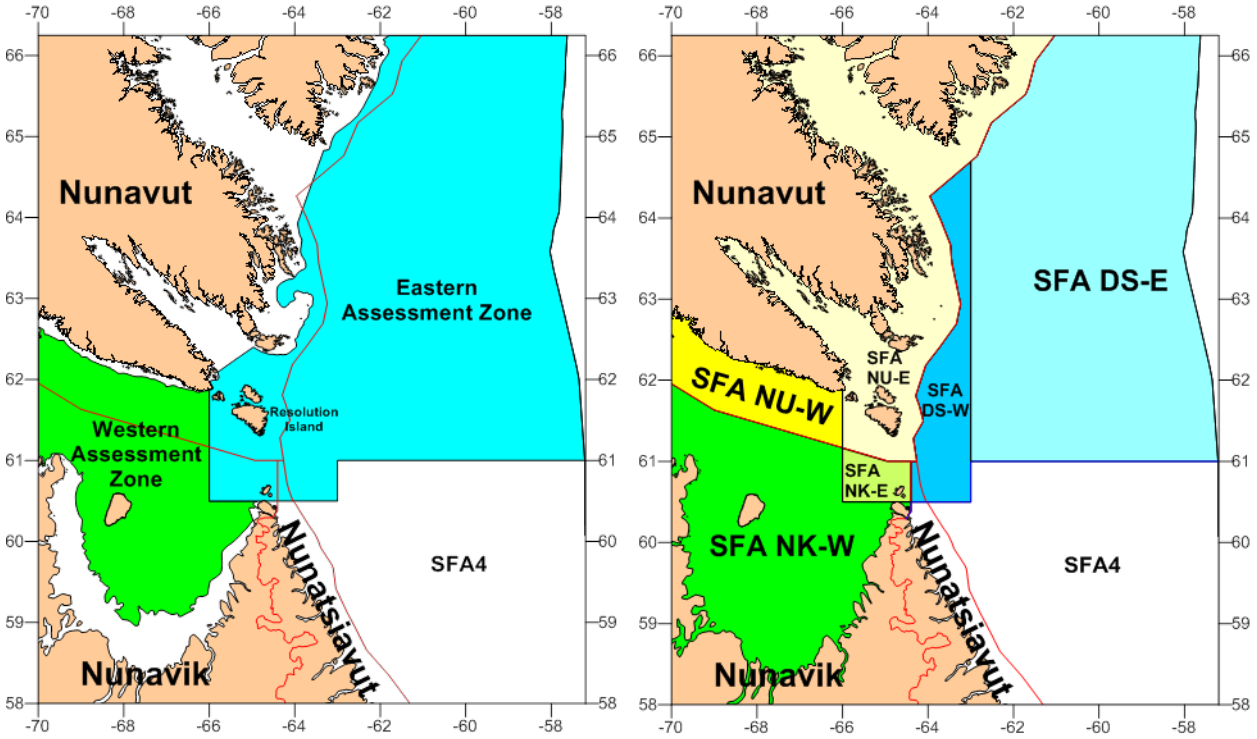

Figure 1. Location of the Western and Eastern assessment zones (left panel) and corresponding Shrimp Fishing Area (SFA) management units (right panel). Boundaries of the Nunavut (NU), Nunavik (NK) and Nunatsiavut Land Claims Areas are identified with red lines. Abbreviations for Davis Strait (DS), East (E) and West (W) are used.

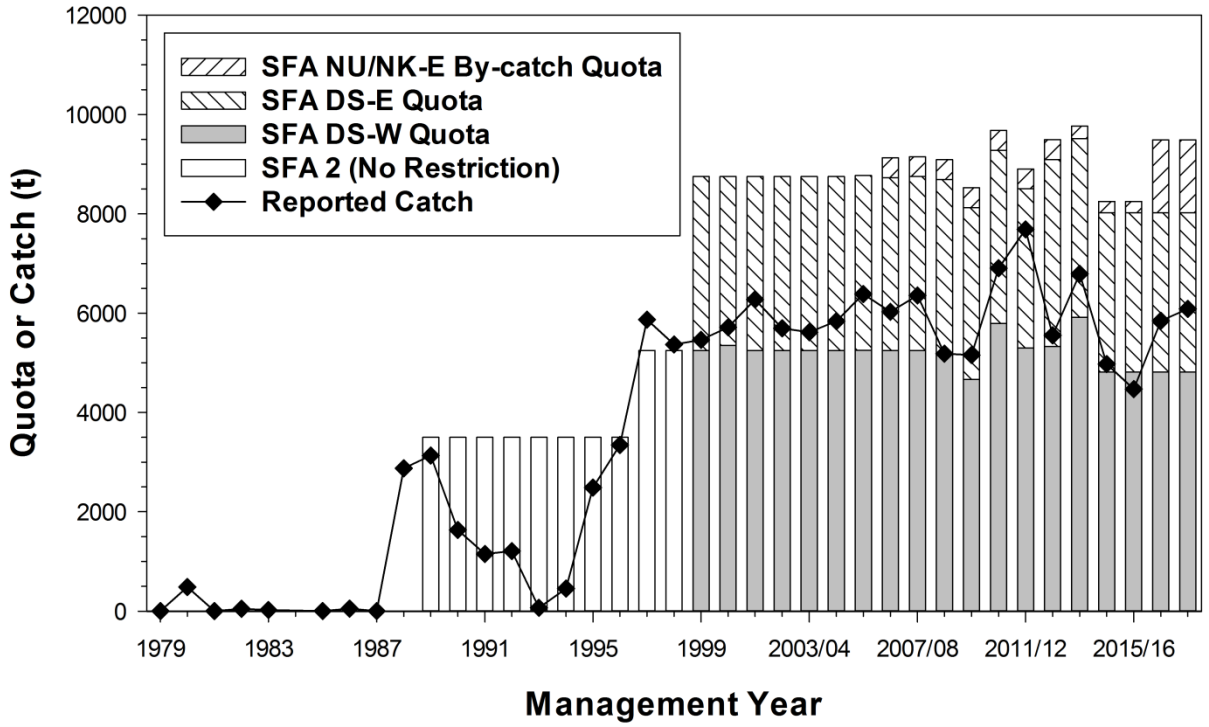

Figure 2. Eastern Assessment Zone Pandalus borealis *TAC and catch recorded in the CAQR. Catch based on CAQR as of 23 January 2018; since fishery is still open the catch is not complete for 2017/18. Quota for 1999-2012/13 renamed to correspond to new management areas.*

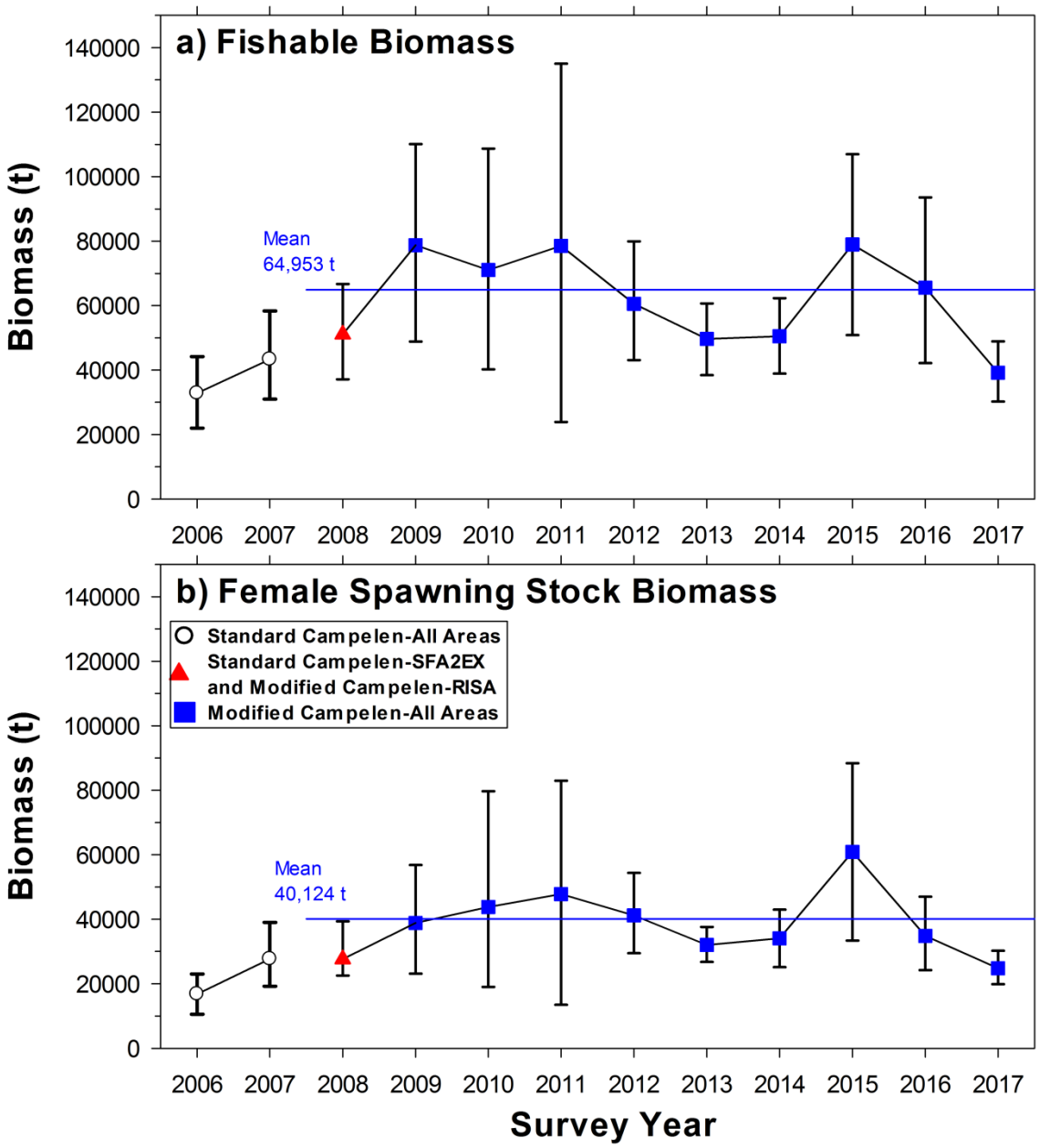

Figure 3. Eastern Assessment Zone Pandalus borealis *a) fishable and b) female spawning stock biomass indices for the survey years 2006-2017. Error bars are 95% confidence ranges.*

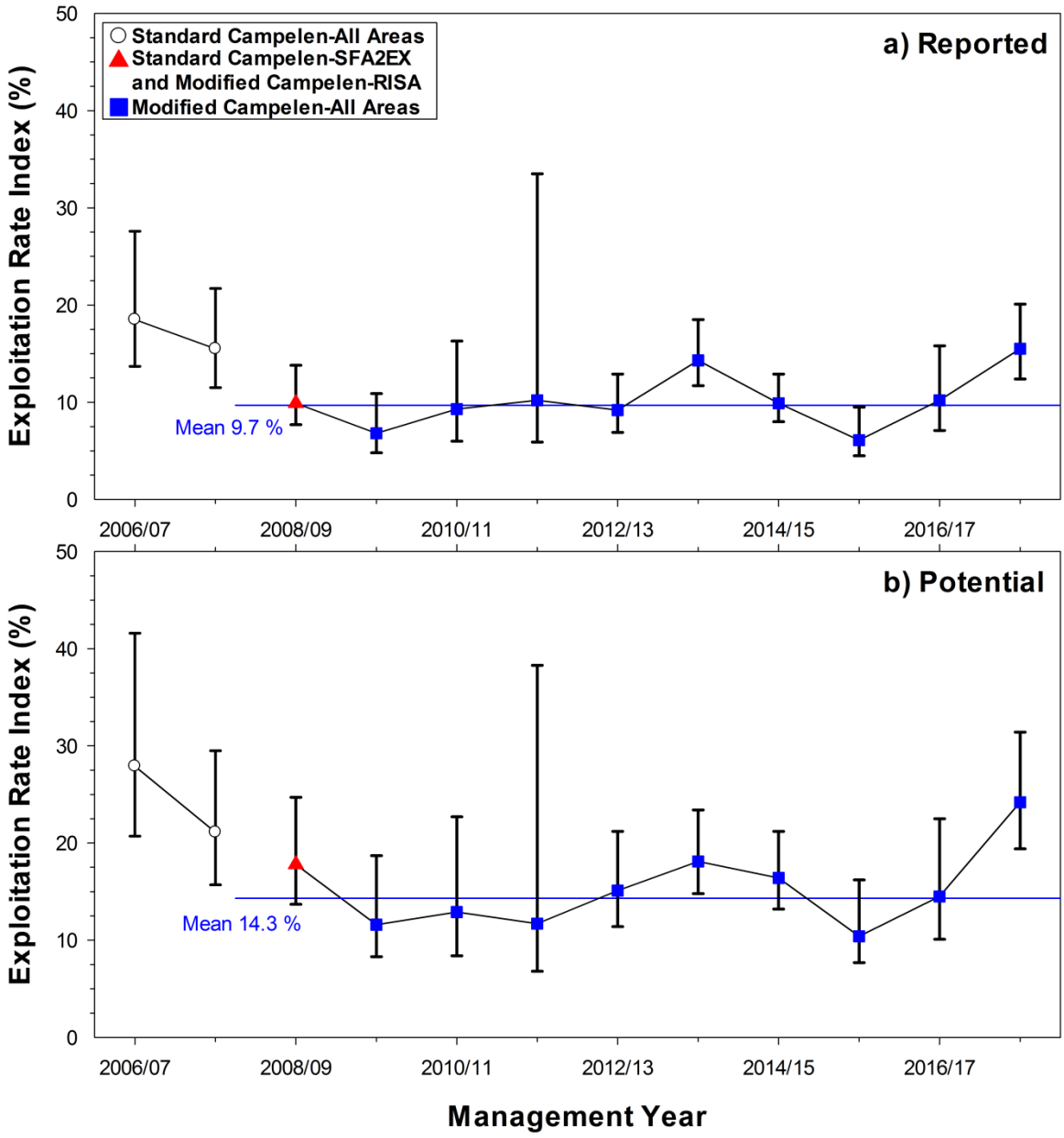

Figure 4. Eastern Assessment Zone Pandalus borealis *a) reported and b) potential exploitation rate indices for the period of 2006/07-2017/18. Error bars are 95% confidence ranges.*

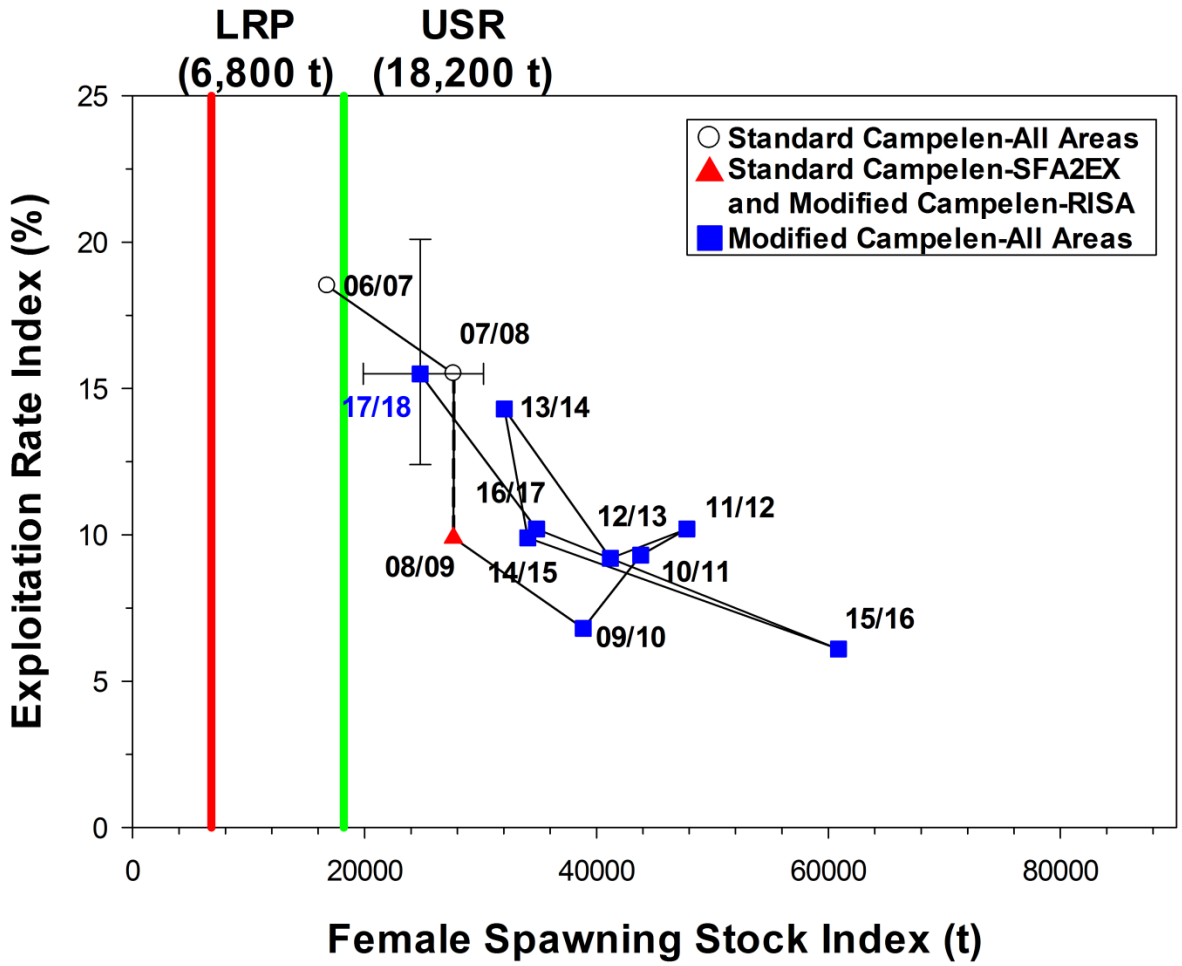

Figure 5. Eastern Assessment Zone trajectory of Pandalus borealis *female spawning stock biomass and exploitation rate indices in relation to reference points. USR=Upper Stock Reference and LRP=Limit Reference Point. Error bars are 95% confidence ranges.*

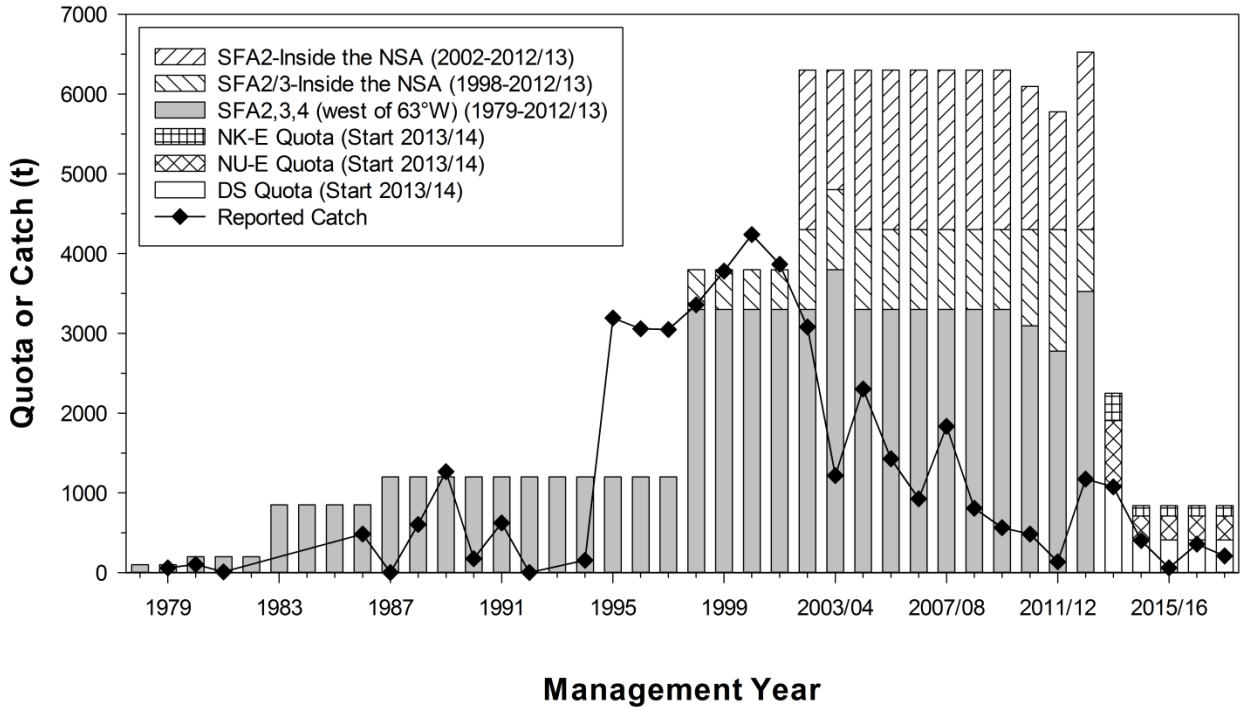

Figure 6. Eastern Assessment Zone Pandalus montagui *TAC and catch recorded in the CAQR. Catch based on CAQR as of 23 January 2018. Since fishery is still open the catch is not complete for 2017/18. New management units were implemented for the 2013/14 season.*

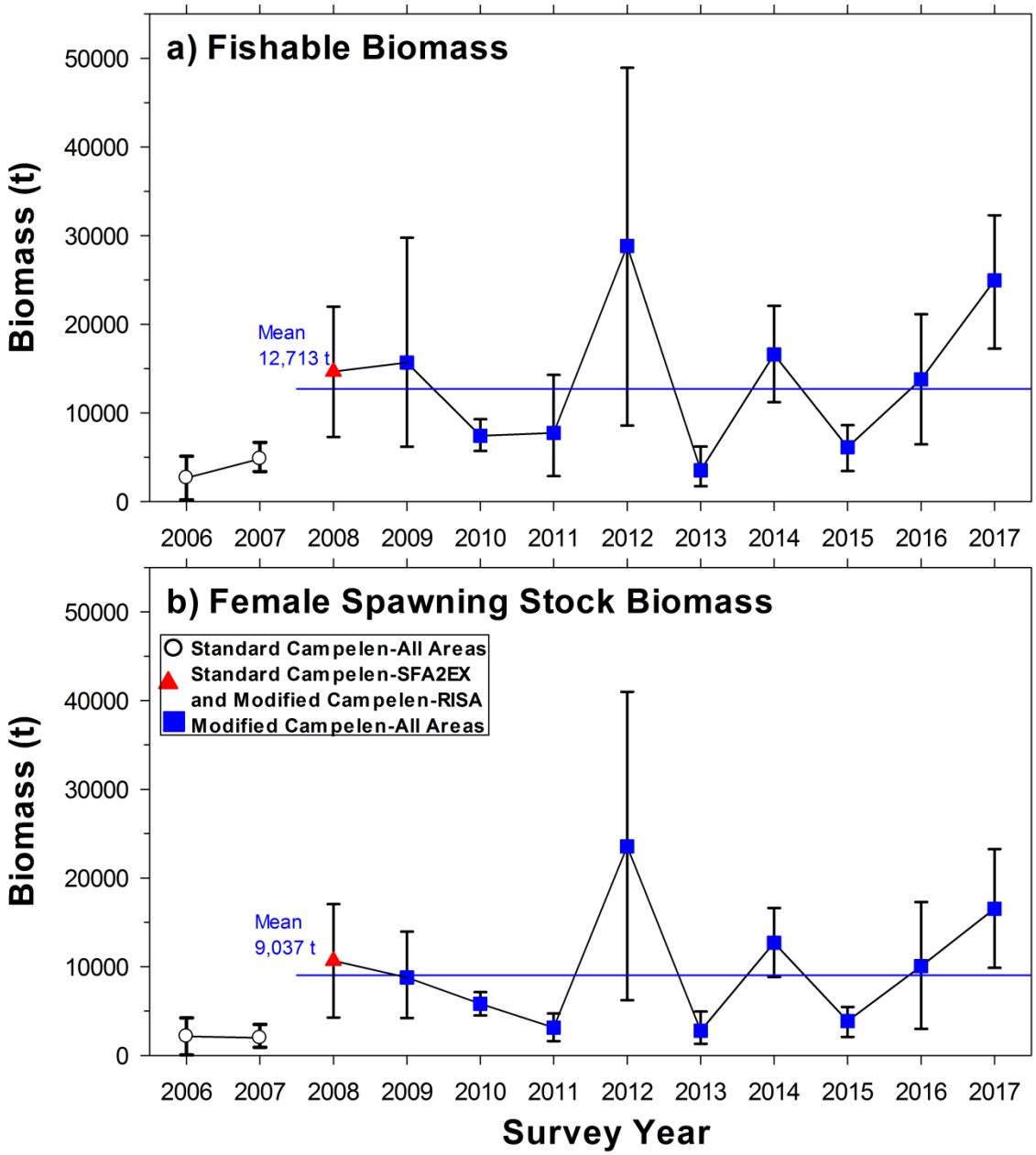

Figure 7. Eastern Assessment Zone Pandalus montagui *a) fishable and b) female spawning stock biomass indices for the survey years 2006-2017. Error bars are 95% confidence ranges.*

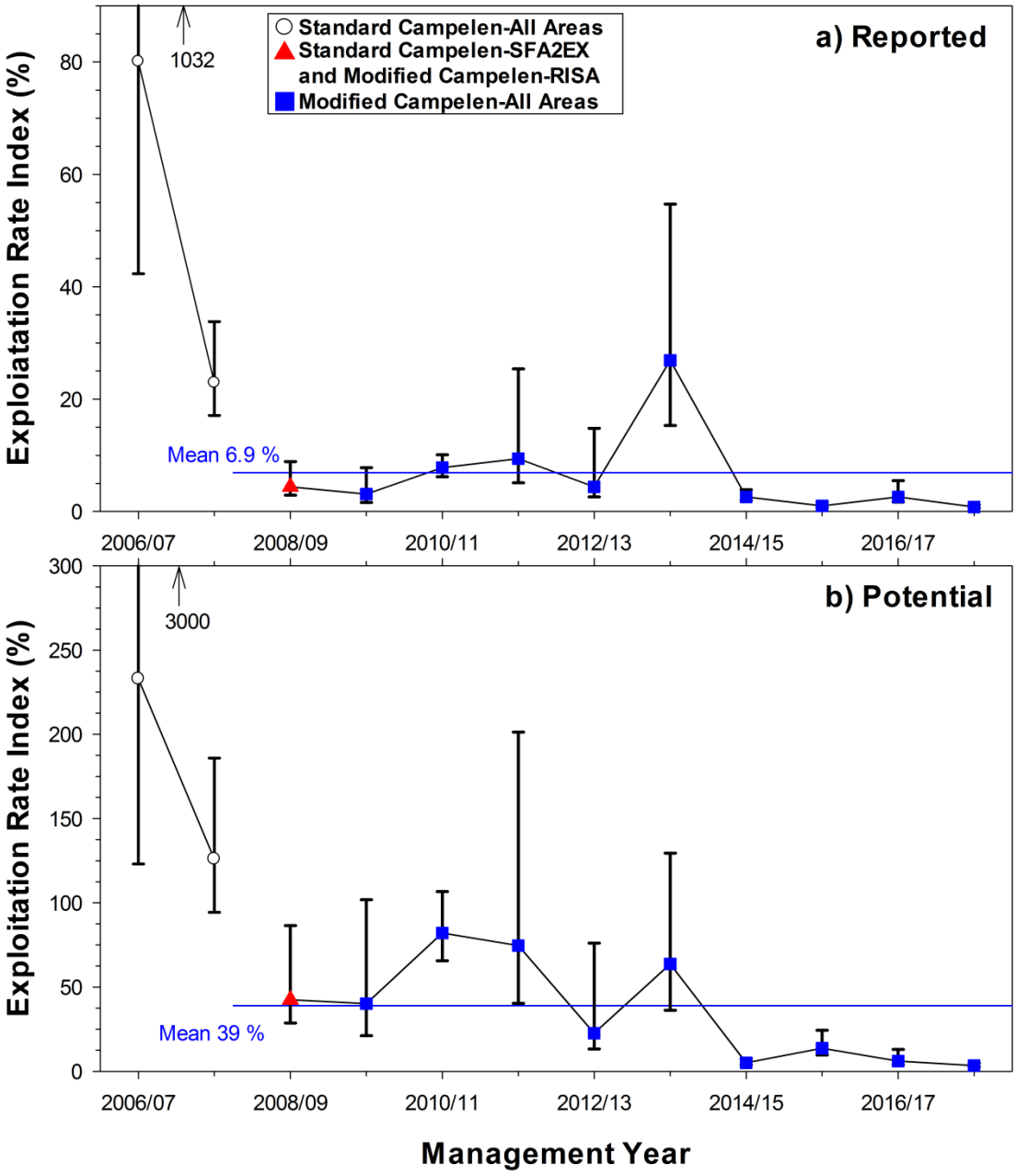

Figure 8. Eastern Assessment Zone Pandalus montagui *a) reported and b) potential exploitation rate indices for 2006/07-2017/18. Error bars are 95% confidence ranges.*

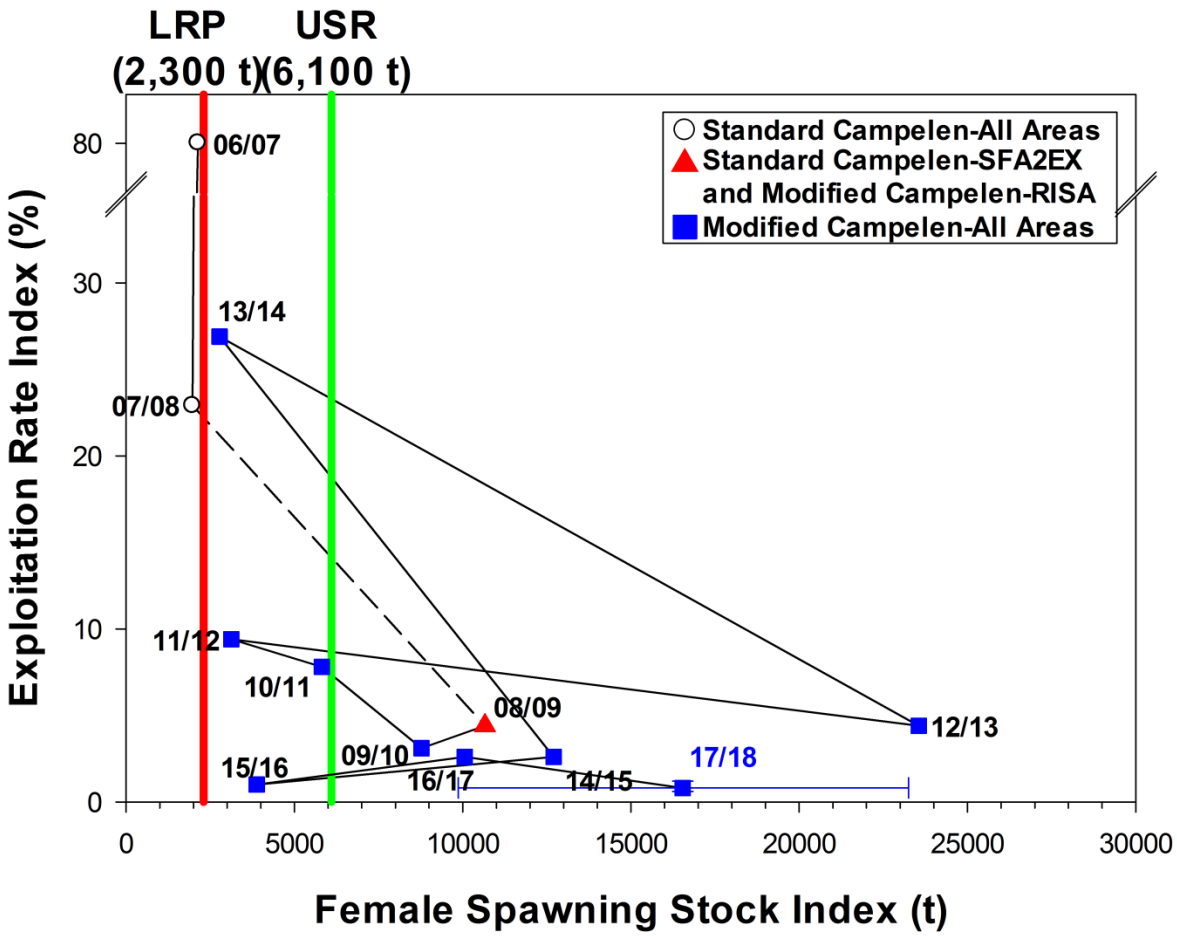

Figure 9. Eastern Assessment Zone trajectory of Pandalus montagui *female spawning stock biomass and exploitation rate indices in relation to reference points. USR=Upper Stock Reference and LRP=Limit Reference Point.*

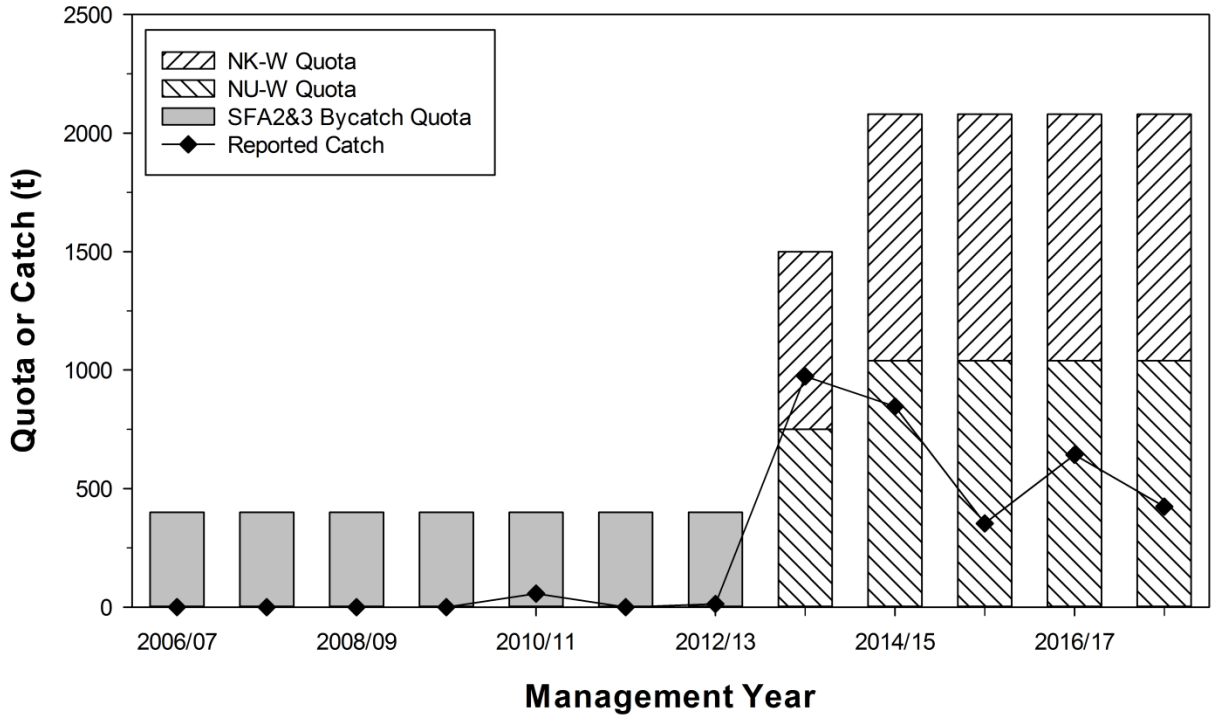

Figure 10. Western Assessment Zone Pandalus borealis *TAC and catch recorded in the CAQR. Catch based on CAQR as of 23 January 2018; since the fishery is still open the catch is not complete for 2018. New management units were implemented for the 2013/14 season.*

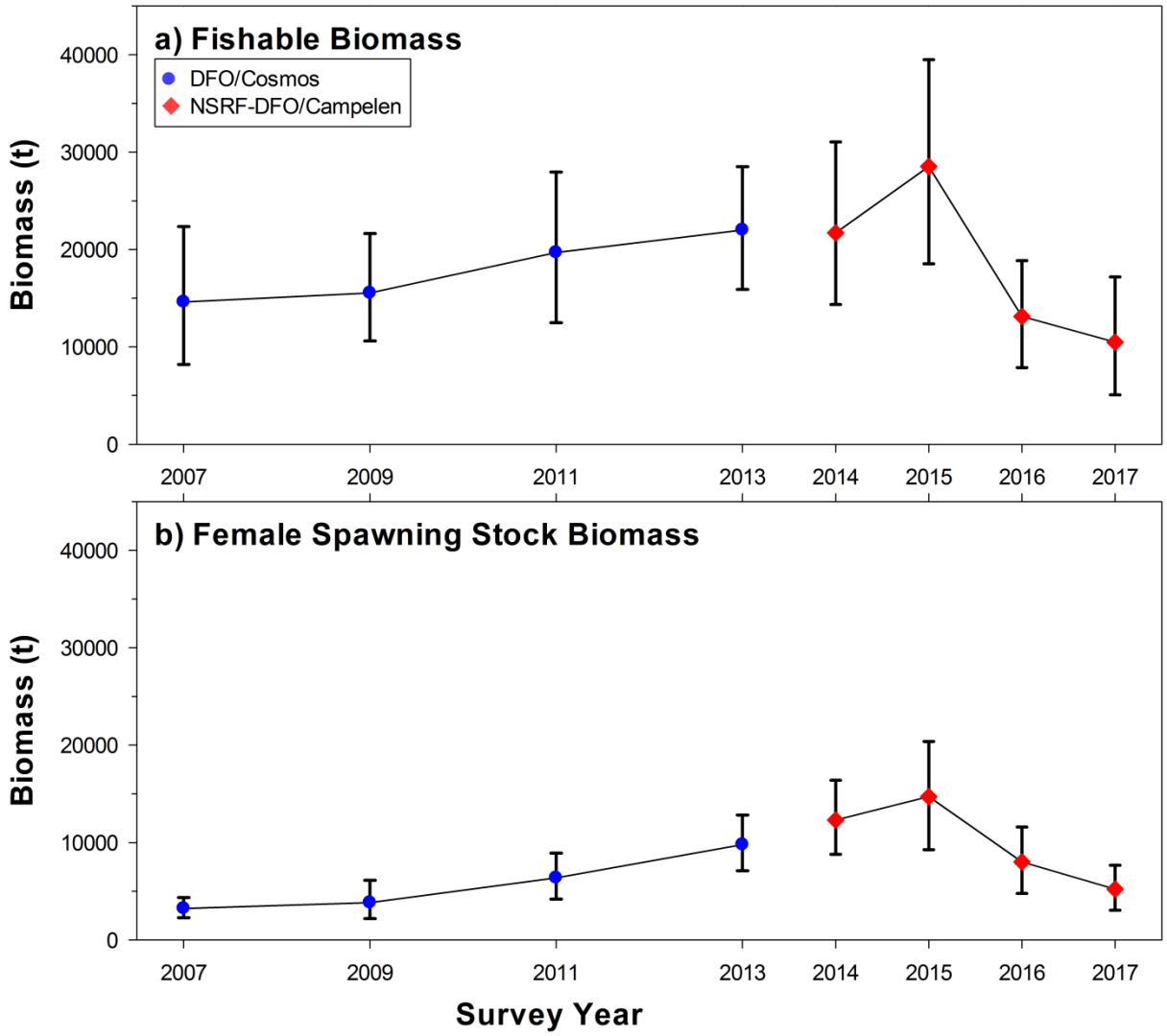

Figure 11. Western Assessment Zone Pandalus borealis, *a) fishable biomass and b) female spawning stock biomass indices for the four years of DFO/Cosmos surveys and four years conducted by the NSRF-DFO/Campelen. Biomass indices from the two surveys are not directly comparable. 2014 represents the start of a new time series for the WAZ. Error bars are 95% confidence ranges.*

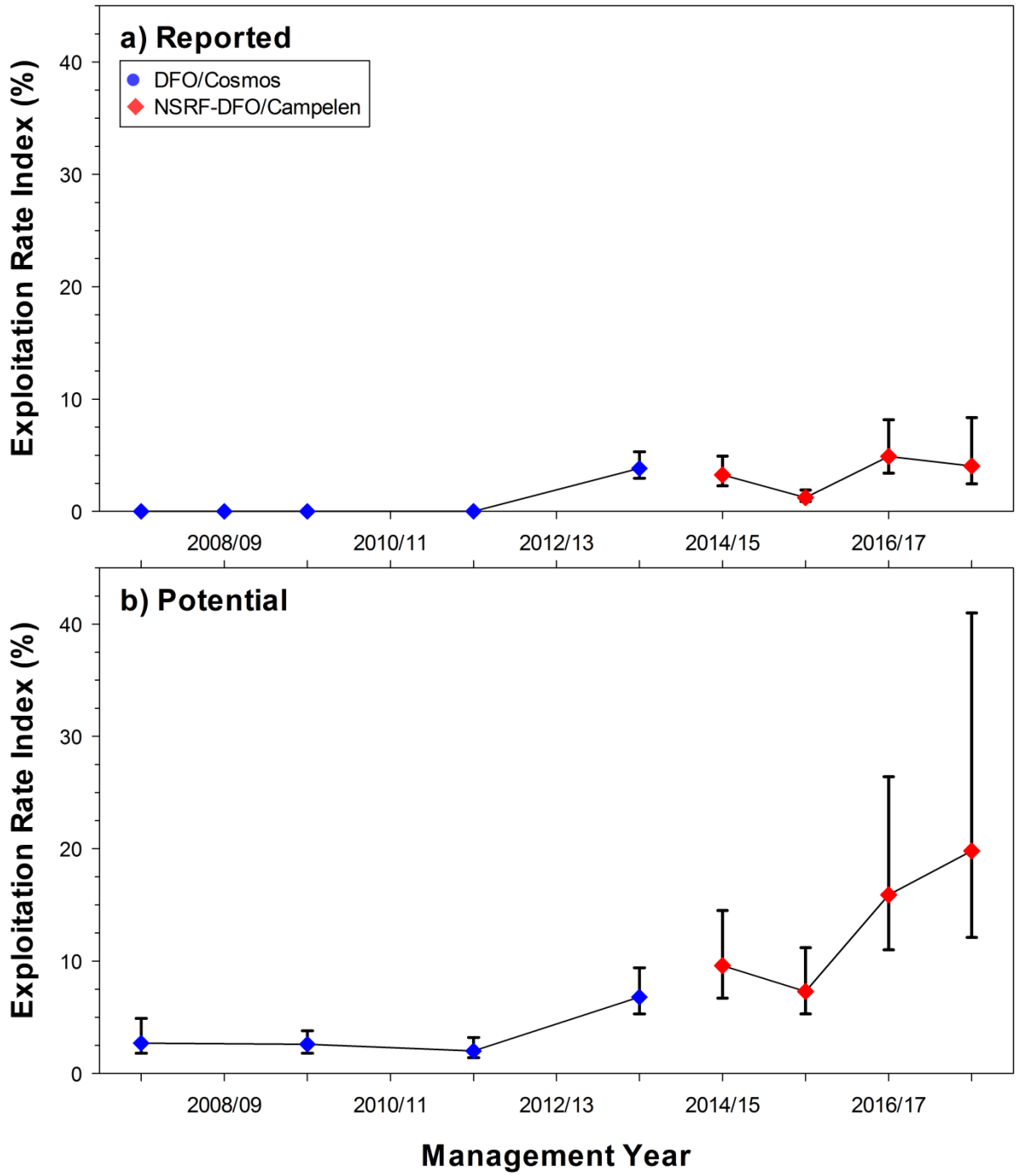

Figure 12. Western Assessment Zone Pandalus borealis *a) reported and b) potential exploitation rate indices for the four years of DFO/Cosmos surveys and four years conducted by the NSRF-DFO/Campelen. Exploitation rate indices from the two surveys are not directly comparable. 2014 represents the start of a new time series for the WAZ. Error bars are 95% confidence ranges.*

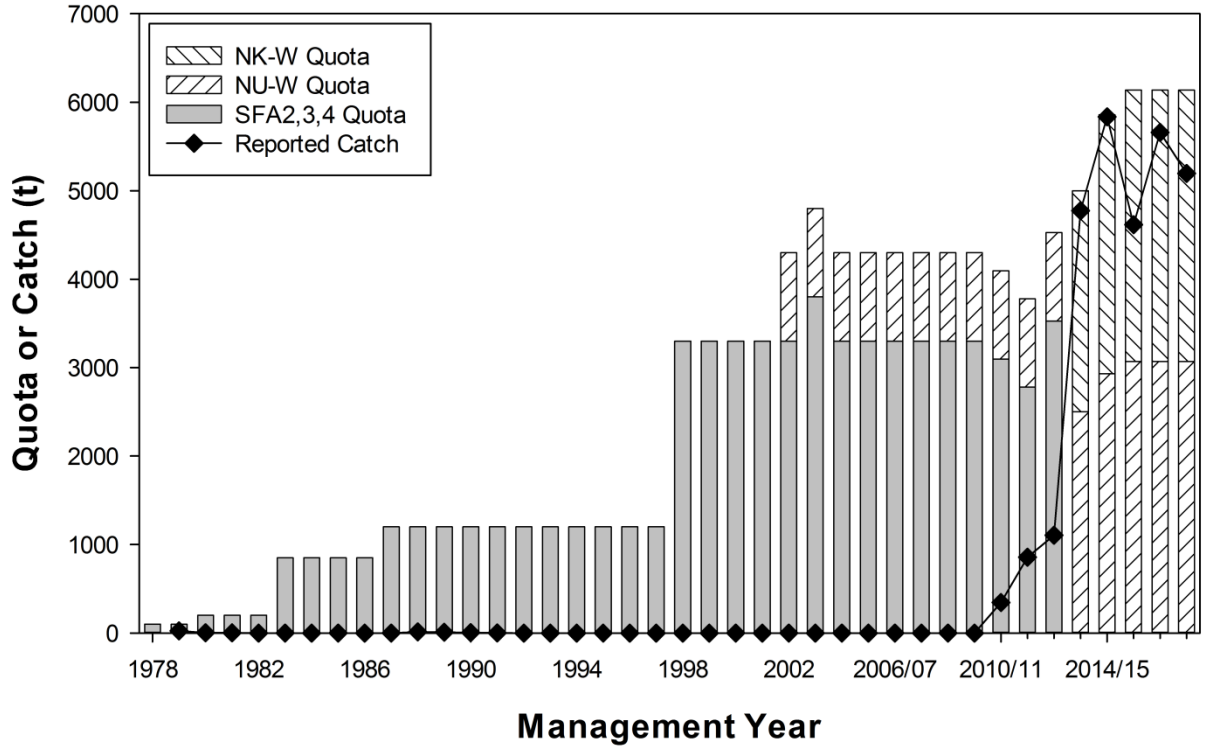

Figure 13. Western Assessment Zone Pandalus montagui *TAC and catch recorded in the CAQR. Catch based on CAQR as of 23 January 2018; since fishery is still open the catch is not complete for 2017/18. New management units implemented for the 2013/14 season.*

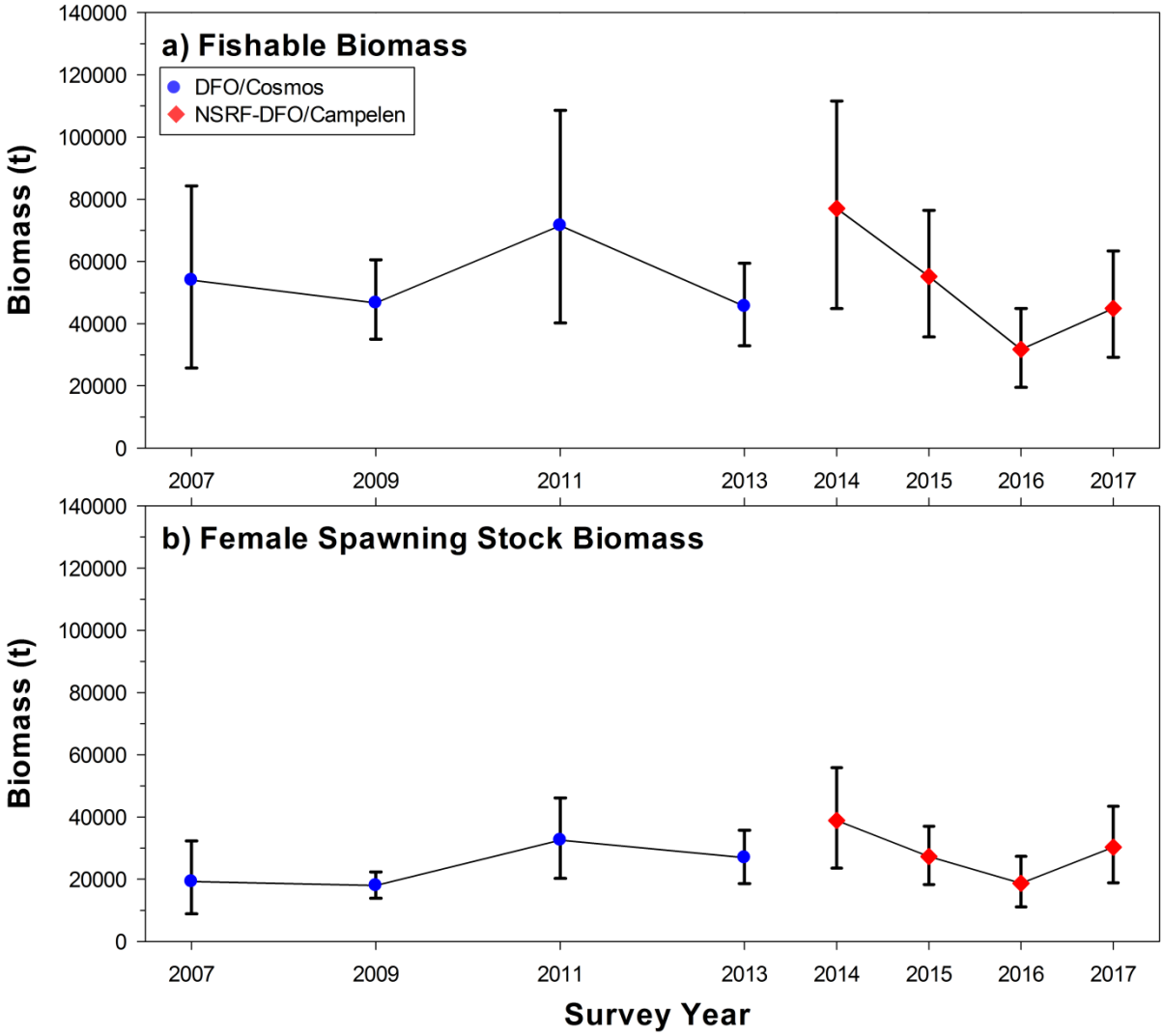

Figure 14. Western Assessment Zone Pandalus montagui*, a) fishable biomass and b) female spawning stock biomass indices for the four years of DFO/Cosmos surveys and four years conducted by the NSRF-DFO/Campelen. Biomass indices from the two surveys are not directly comparable. 2014 represents the start of a new time series for the WAZ. Error bars are 95% confidence ranges.*

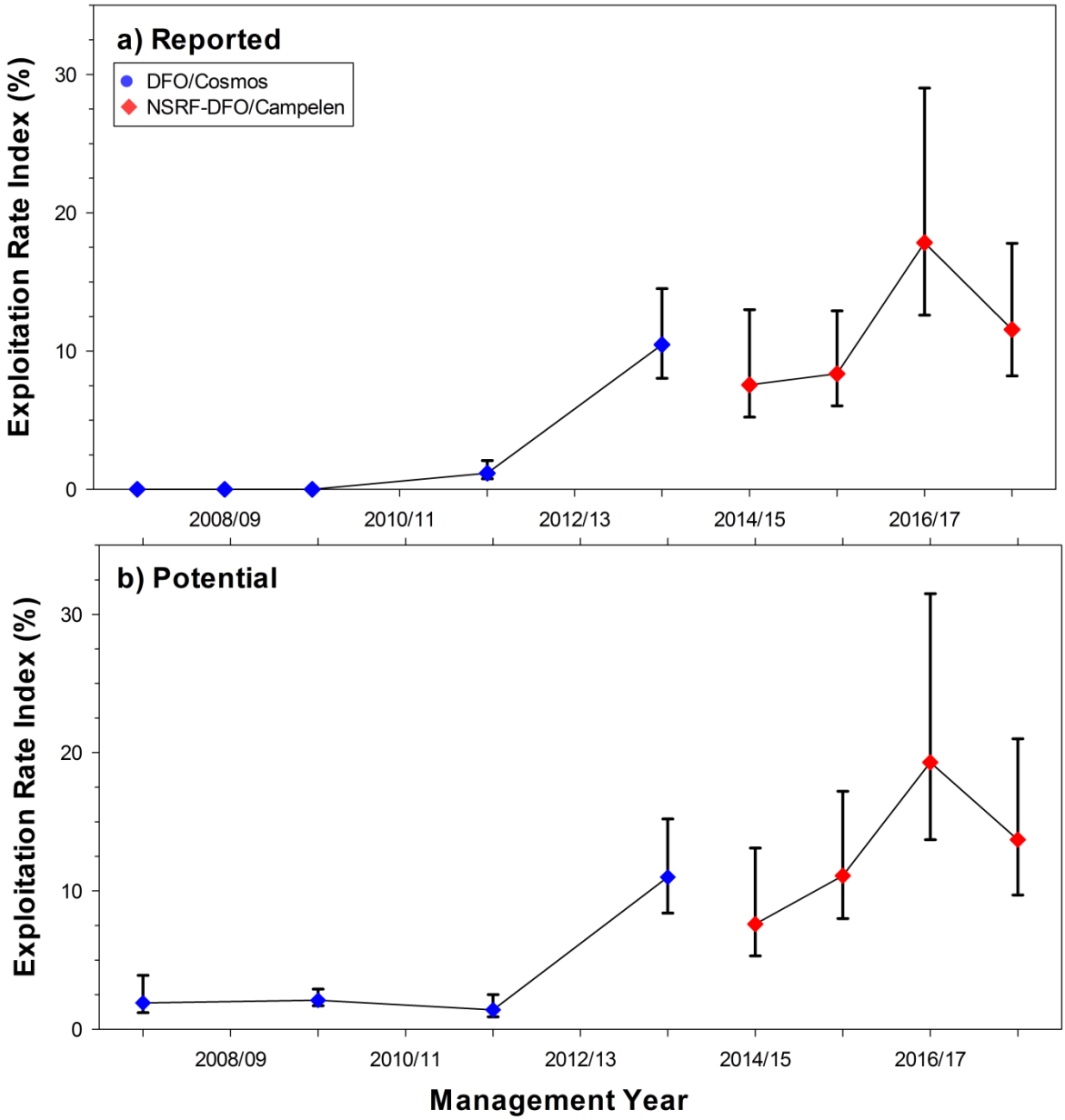

Figure 15. Western Assessment Zone Pandalus montagui *a) reported and b) potential exploitation rate indices for the four years of DFO/Cosmos surveys and four years conducted by the NSRF-DFO/Campelen. Exploitation rate indices from the two surveys are not directly comparable. 2014 represents the start of a new time series for the WAZ. Error bars are 95% confidence ranges.*

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