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 2020/014**

UPDATE OF STOCK STATUS INDICATORS FOR NORTHERN SHRIMP, *PANDALUS BOREALIS,* AND STRIPED SHRIMP, *PANDALUS MONTAGUI,* IN THE WESTERN AND EASTERN ASSESSMENT ZONES, JANUARY 2020

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 2019 (DFO 2019). 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 2019/20 fishing season.

This Science Response Report results from the Science Response Process (SRP) of January 28, 2020 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 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 is calculated as though 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 DFO-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. Currently, there are no RPs 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 the Canadian Atlantic Quota Report (CAQR), as of 7 January 2020, was 4,687 t, which is 56% of the TAC (Table 1, Figure 2). The 2019/20 fishery runs until 31 March 2020, thus catch records should be considered preliminary for 2019/20.

Biomass

The fishable biomass index increased by 102.8% from 2018 to 2019 and is now at the highest level (95,138 t) since the time series began (Table 2, Figure 3a). The female SSB index showed an increase of 74.0% and is currently at the second highest level (57,143 t) (Table 2, Figure 3b).

Exploitation

The reported exploitation rate (ER) index for 2019/20, as of 7January 2020, was 4.9% (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 2019/20 would be 8.8% (Figure 4b). The long term average of the potential ER is 15.4%, which is near the base target ER of 15% in the Healthy Zone for the EAZ (DFO 2018).

Current Outlook

The female SSB index for *P. borealis* in the EAZ is well 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 7 January 2020, was about 113 t (Table 1, Figure 6) and has been declining since 2001. The 2019/20 fishery runs until 31 March 2020, thus catch records are preliminary for 2019/20.

Biomass

Biomass indices for *P. montagui* in the EAZ have 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 decreased in 2019 to 8,503 t and 4,415 t, respectively, and were below the long term mean (Table 3, Figure 7a,b).

Exploitation

The reported ER index for 2019/20 was very low, 1.0%, due to low catches reported in the CAQR as of 7 January 2020 (Figure 8a). The potential ER index for this stock would be 9.9% if the entire TAC is taken (Figure 8b).

Current Outlook

The female SSB index in the EAZ has declined in 2019 placing the stock in the Cautious Zone (Figure 9). Given the wide fluctuations in biomass indices for *P. montagui* observed in the past (e.g., between years 2011, 2012 and 2013, and also last year) the status of this resource is considered uncertain.

Western Assessment Zone – *P. borealis*

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

Fishery

As of 7 January 2020, the CAQR records show that about 620 t, which equals to 19.6% of the TAC, have been taken (Table 1, Figure 10).

Biomass

The fishable biomass and female SSB indices decreased from 2018 to 2019 by 3.4% and 8.1%, respectively (Table 4, Figure 11a,b). The fishable biomass index in 2019 was 20,378 t, which was in the close proximity of the time series mean. The female SSB index was 11,845 t, which was above the time series mean.

Exploitation

The reported ER index for 2019/20 was relatively low, 3.4%, due to low catches reported in the CAQR as of 7 January 2020 (Figure 12a). As a consequence of the decline in the fishable biomass in 2019, the potential ER index has increased to about 15.5% (Figure 12b).

Current Outlook

Currently, there is no PA framework for *P. borealis* in the WAZ. The establishment of reference points for this resource is planned for 2020, to be implemented in 2021 stock assessment. 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 six years of survey data can be considered in the WAZ assessment because of the change in the surveys, resulting in the start of a new time series.

Fishery

The total catch of *P. montagui* was 6,884 t, which is 57.5% of the TAC as per 7 January 2020 CAQR (Table 1, Figure 13). The 2019/20 fishery runs until 31 March 2020 thus catch records should be considered preliminary for the 2019/20 season.

Biomass

The fishable biomass index decreased by 19.5%[1] from 2018 to 2019, with 64,268 t observed in 2019 (Table 5, Figure 14a), which was above the time series mean. A more pronounced biomass decrease (37.2%) was observed for the female SSB index, with 29,079 t estimated in 2019, which was in the close proximity of the time series mean (Figure 14b).

Exploitation

Along with decreasing fishable biomass, the reported ER index in 2019/20 increased to 11.3% (Figure 15a). If the entire TAC was taken the potential ER index would be 18.6% (Figure15b).

Current Outlook

Currently, there is no PA framework for *P. montagui* in the WAZ. The establishment of reference points for this resource is planned for 2020, to be implemented in 2021 stock assessment. Historical records show that the TAC for this stock has often been nearly fully taken. With the recently increased TAC it is unlikely that it will be fully taken in 2019.

Conclusions

Eastern Assessment Zone (EAZ)

Pandalus borealis

- Currently, the *Pandalus borealis* resource is in the Healthy Zone of the Precautionary Approach Framework.
- In 2019, the fishable biomass and female spawning stock biomass indices recorded relatively large increases; the fishable biomass is at the highest level while the female spawning stock biomass is at the second highest level since the time series began.
- The potential Exploitation Rate (ER) index for 2019/20 is 8.8%. That is below both the long term mean of the potential ER (15.4%) and the base target ER of 15% in the Healthy Zone 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 decrease in the biomass, the *Pandalus montagui* resource is currently in the Cautious Zone of the Precautionary Approach Framework.

[1] Erratum February 2020 – 17.5% now reads 19.5%

- The potential exploitation rate index if the entire TAC is taken in 2019/20 would be 9.9%.

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 declined slightly from 2018 to 2019.
- The reported exploitation rate index for 2019/20 is 3.4%. The current TAC equates to a potential exploitation rate index of 15.5%.

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 decreased from 2018 to 2019.
- The reported exploitation rate index for 2019/20 is 11.3%; the potential exploitation rate index for 2019/20 is 18.6%.

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Appendix 1. Tables

Table 1. Nominal reported catches (t) 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***
2019*	4687	113	620	6884
2018	6198	234	1307	5531
2017	6488	233	918	5609
2016	6667	358	643	5660
2015	4816	59	353	4616
2014	4972	401	847	5836
2013	6793	1075	973	4775
2012	5555	1173	13	1105
2011	7687	135	0	857
2010	6908	483	57	345
2009	5159	564	0	0
2008	5184	808	0	0
2007	6359	1832	0	0
2006	6028	925	0	0
2005	6387	1427	-	0
2004	5842	2301	-	0
2003	5617	1217	-	0
2002	5695	3081	-	0
2001	6275	3867	-	0
2000	5718	4238	-	0
1999	5465	3780	-	0
1998	5372	3360	-	0
1997	5870	3050	-	0
1996	33467	3058	-	0
1995	2489	3192	-	0
1994	456	154	-	0
1993	68	0	-	0
1992	1210	1	-	0
1991	1150	623	-	0
1990	1634	174	-	5
1989	3133	1265	-	10
1988	2873	603	-	13
1987	0	0	-	0

Table 1. continued

Year	Eastern Assessment Zone		Western Assessment Zone	
	P. borealis	***P. montagui***	***P. borealis***	***P. montagui***
1986	50	483	-	0
1985	0	0	-	0
1984	0	0	-	0
1983	21	0	-	0
1982	46	0	-	0
1981	1	9	-	2
1980	487	103	-	3
1979	1	58	-	25

** Catch based on CAQR as of 7 January 2020. Since the fishery is still open the catch is preliminary for 2019.*

Table 2. Fishable and female spawning stock biomass estimates for Pandalus borealis *in the Eastern Assessment Zone for the 2006-2019 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
2019	Fishable	102.8	95138	48333	146788
2018	Fishable	19.6	46900	36344	58928
2017	Fishable	-40.2	39198	30225	48907
2016	Fishable	-17.0	65570	42137	93569
2015	Fishable	56.5	78984	50852	106962
2014	Fishable	1.5	50458	38914	62340
2013	Fishable	-17.9	49697	38427	60631
2012	Fishable	-22.9	60534	43074	79960
2011	Fishable	10.5	78530	23900	135037
2010	Fishable	-9.8	71065	40234	108703
2009	Fishable	54.3	78755	48850	110115
2008	Fishable	17.9	51053	37117	66708
2007	Fishable	32.0	43306	31015	58346
2006	Fishable	-	32816	21969	44152
2019	Female SS	74.0	57143	28420	87654
2018	Female SS	32.4	32842	23548	44126
2017	Female SS	-28.8	24800	19888	30252
2016	Female SS	-42.8	34827	24220	46979
2015	Female SS	78.7	60869	33379	88386
2014	Female SS	6.3	34069	25157	43000
2013	Female SS	-22.2	32049	26762	37607
2012	Female SS	-13.8	41190	29498	54383
2011	Female SS	9.1	47807	13470	82926
2010	Female SS	12.7	43800	19025	79665
2009	Female SS	40.5	38856	23122	56820
2008	Female SS	-0.2	27653	22507	39368
2007	Female SS	64.8	27698	19249	39007
2006	Female SS	-	16805	10523	23026

Table 3. Fishable and female spawning stock biomass estimates for Pandalus montagui *in the Eastern Assessment Zone for the 2006-2019 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
2019	Fishable	-59.3	8503	3930	13948
2018	Fishable	-16.3	20895	12617	29450
2017	Fishable	81.0	24957	17246	32311
2016	Fishable	124.7	13792	6452	21126
2015	Fishable	-63.0	6137	3445	8629
2014	Fishable	371.0	16600	11203	22084
2013	Fishable	-87.8	3524	1738	6208
2012	Fishable	272.7	28845	8582	48946
2011	Fishable	4.3	7740	2871	14285
2010	Fishable	-52.7	7423	5714	9290
2009	Fishable	6.9	15679	6190	29774
2008	Fishable	203.8	14667	7287	21973
2007	Fishable	81.0	4828	3389	6673
2006	Fishable	-	2667	210	5122
2019	Female SS	-68.0	4415	1742	7275
2018	Female SS	-19.8	13806	9362	20052
2017	Female SS	64.4	16537	9866	23250
2016	Female SS	159.4	10056	2986	17280
2015	Female SS	-69.5	3877	2085	5452
2014	Female SS	357.1	12696	8834	16622
2013	Female SS	-88.2	2778	1301	4949
2012	Female SS	653.8	23552	6218	40985
2011	Female SS	-46.3	3124	1599	4721
2010	Female SS	-33.7	5819	4509	7136
2009	Female SS	-17.7	8776	4205	13955
2008	Female SS	440.9	10660	4269	17047
2007	Female SS	-7.7	1971	903	3490
2006	Female SS	-	2134	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
2019	Fishable	-3.4	20378	12852	29080
2018	Fishable	101.0	21088	12627	33452
2017	Fishable	-20.0	10487	5073	17185
2016	Fishable	-54.0	13116	7867	18868
2015	Fishable	31.4	28532	18531	39501
2014	Fishable	-1.3	21713	14353	31046
2013	Fishable	11.7	21999	15906	28518
2011	Fishable	26.7	19692	12468	27961
2009	Fishable	6.4	15544	7613	25529
2007	Fishable	-	14615	4907	28872
2019	Female SS	-8.1	11845	7529	16299
2018	Female SS	147.0	12884	7121	19203
2017	Female SS	-34.9	5216	3045	7676
2016	Female SS	-45.5	8015	4780	11590
2015	Female SS	19.5	14710	9270	20379
2014	Female SS	25.8	12309	8792	16398
2013	Female SS	53.5	9785	7106	12829
2011	Female SS	66.1	6377	4182	8909
2009	Female SS	18.8	3840	1154	7479
2007	Female SS	-	3231	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
2019	Fishable	-19.5	64268	29711	112173
2018	Fishable	77.7	79835	34057	132111
2017	Fishable	41.6	44915	29179	63381
2016	Fishable	-42.5	31724	19507	44908
2015	Fishable	-28.4	55194	35769	76429
2014	Fishable	68.9	77078	44854	111562
2013	Fishable	-36.2	45647	32899	59438
2011	Fishable	53.3	71558	40264	108612
2009	Fishable	-13.6	46673	25756	73342
2007	Fishable	-	54044	17007	99461
2019	Female SS	-39.2	29079	14930	45581
2018	Female SS	57.8	47834	19926	81534
2017	Female SS	62.1	30305	18830	43434
2016	Female SS	-31.6	18691	11090	27334
2015	Female SS	-29.7	27324	18282	37041
2014	Female SS	44.2	38875	23553	55849
2013	Female SS	-17.2	26955	18616	35736
2011	Female SS	80.8	32549	20296	46119
2009	Female SS	-6.6	17999	9775	28160
2007	Female SS	-	19277	5668	36606

Appendix 2. Figures

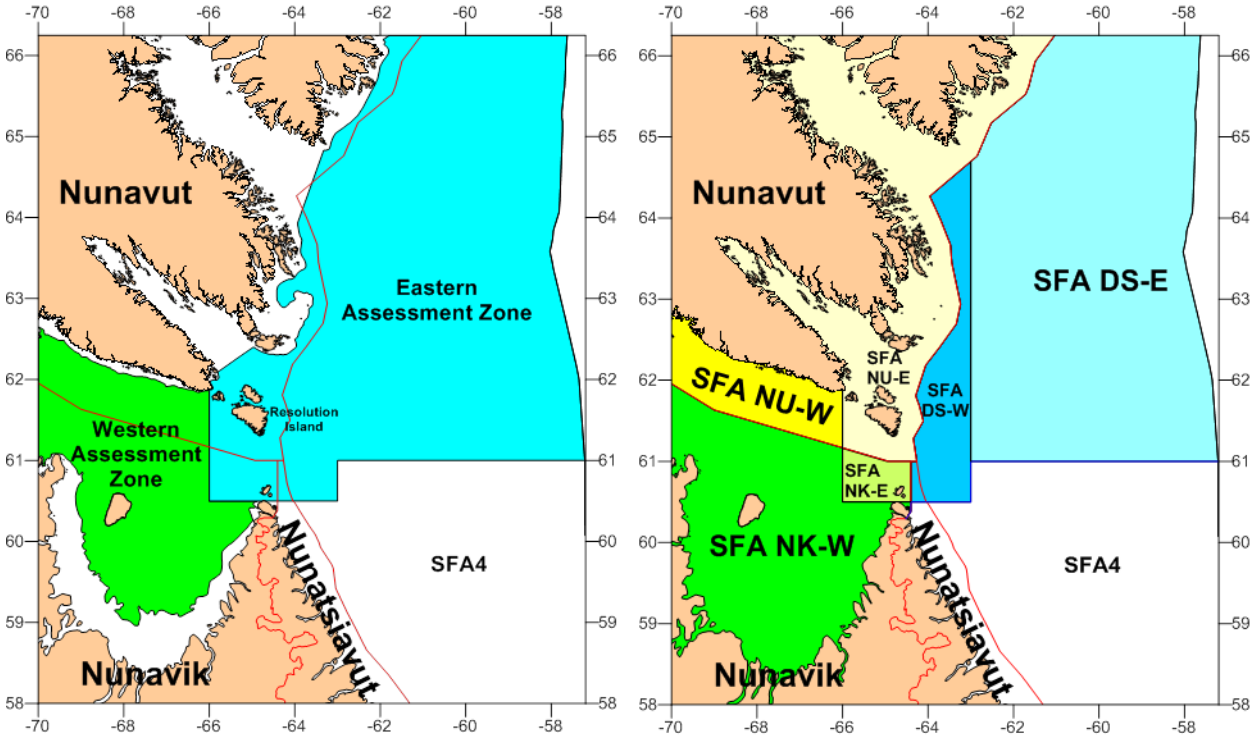

Figure 1. Location of the Western and Eastern assessment zones (left panel) and corresponding Shrimp Fishing Area (SFA) management units (right panel). Boundaries of the Nunavut (NU), Nunavik (NK) and Nunatsiavut Land Claims Areas are identified with red lines. Abbreviations for Davis Strait (DS), East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

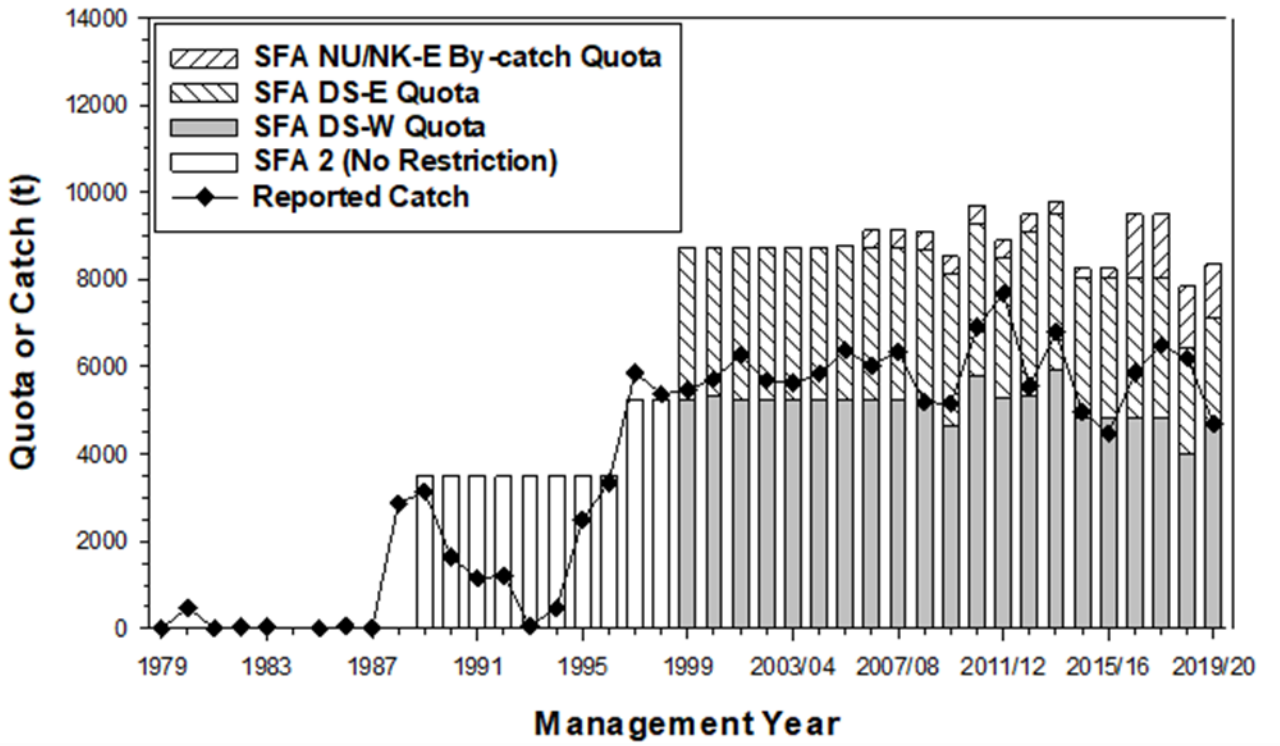

Figure 2. Eastern Assessment Zone Pandalus borealis TAC and catch recorded in the CAQR. Catch based on CAQR as of January 7, 2020; since fishery is still open the catch is not complete for 2019/20. Quota for 1999-2012/13 renamed to correspond to new management areas.

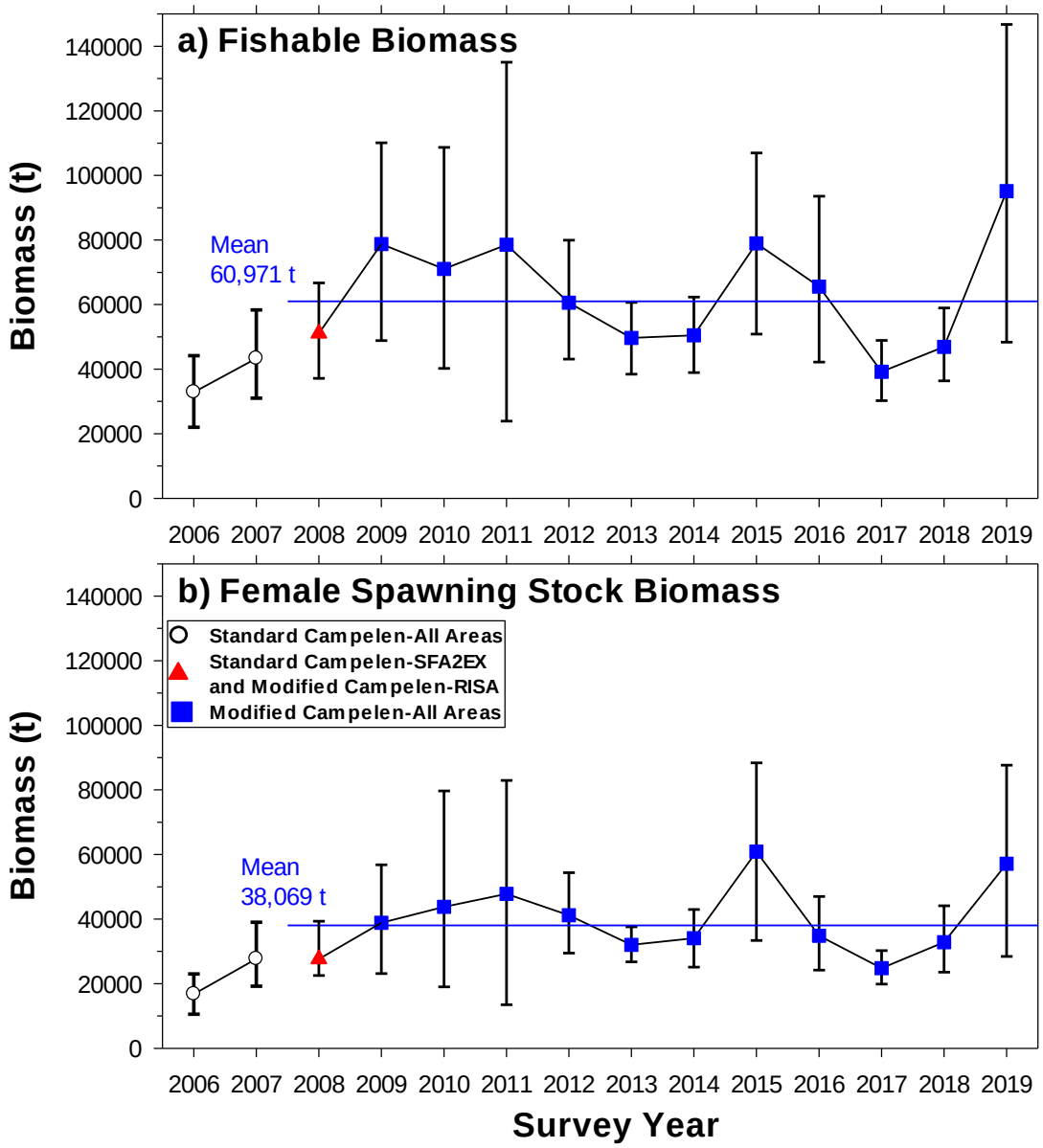

Figure 3. Eastern Assessment Zone Pandalus borealis a) fishable and b) female spawning stock biomass indices for the survey years 2006-2019. Error bars are 95% confidence ranges.

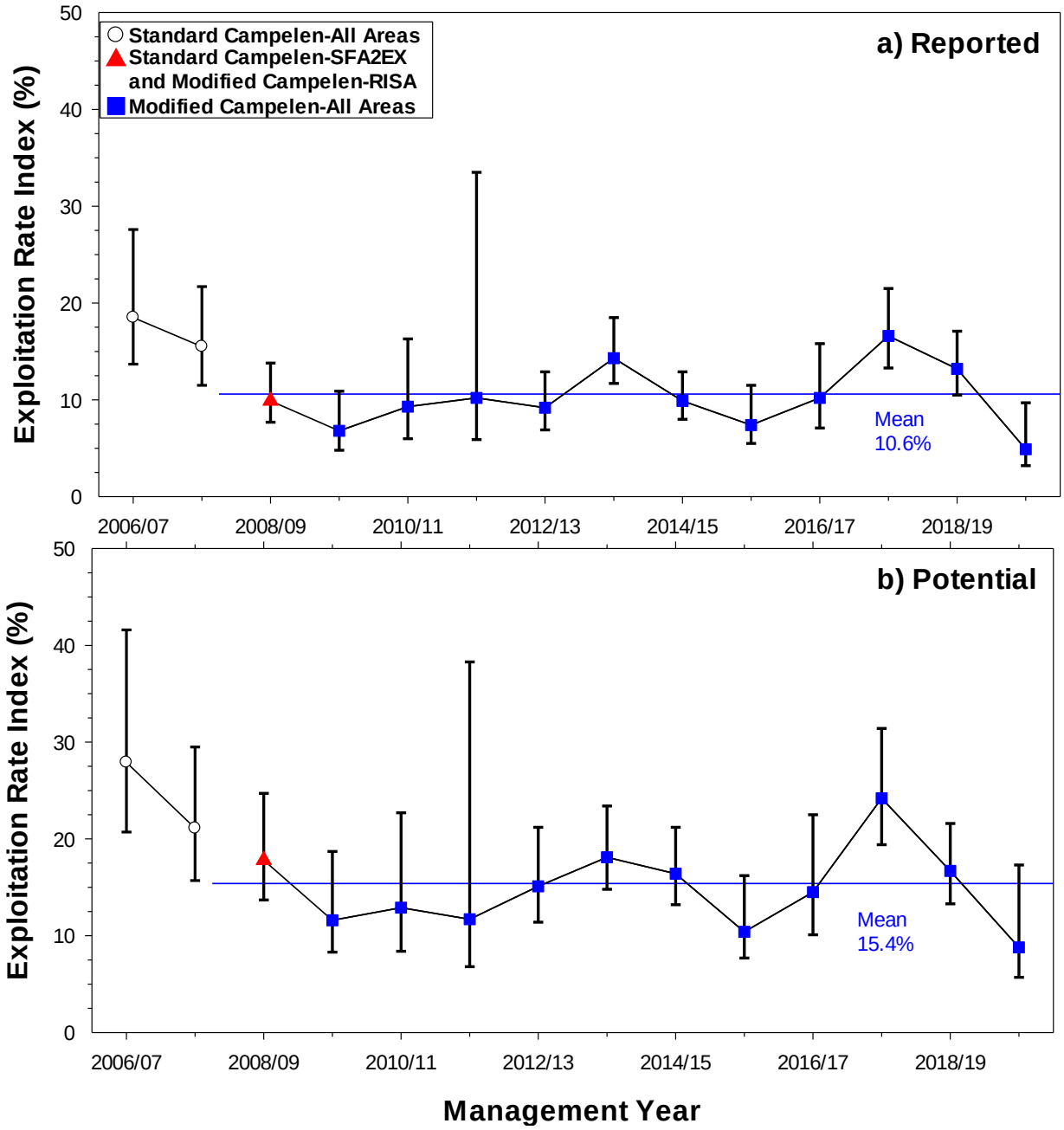

Figure 4. Eastern Assessment Zone Pandalus borealis a) reported and b) potential exploitation rate indices for the period of 2006/07-2019/20. Error bars are 95% confidence ranges.

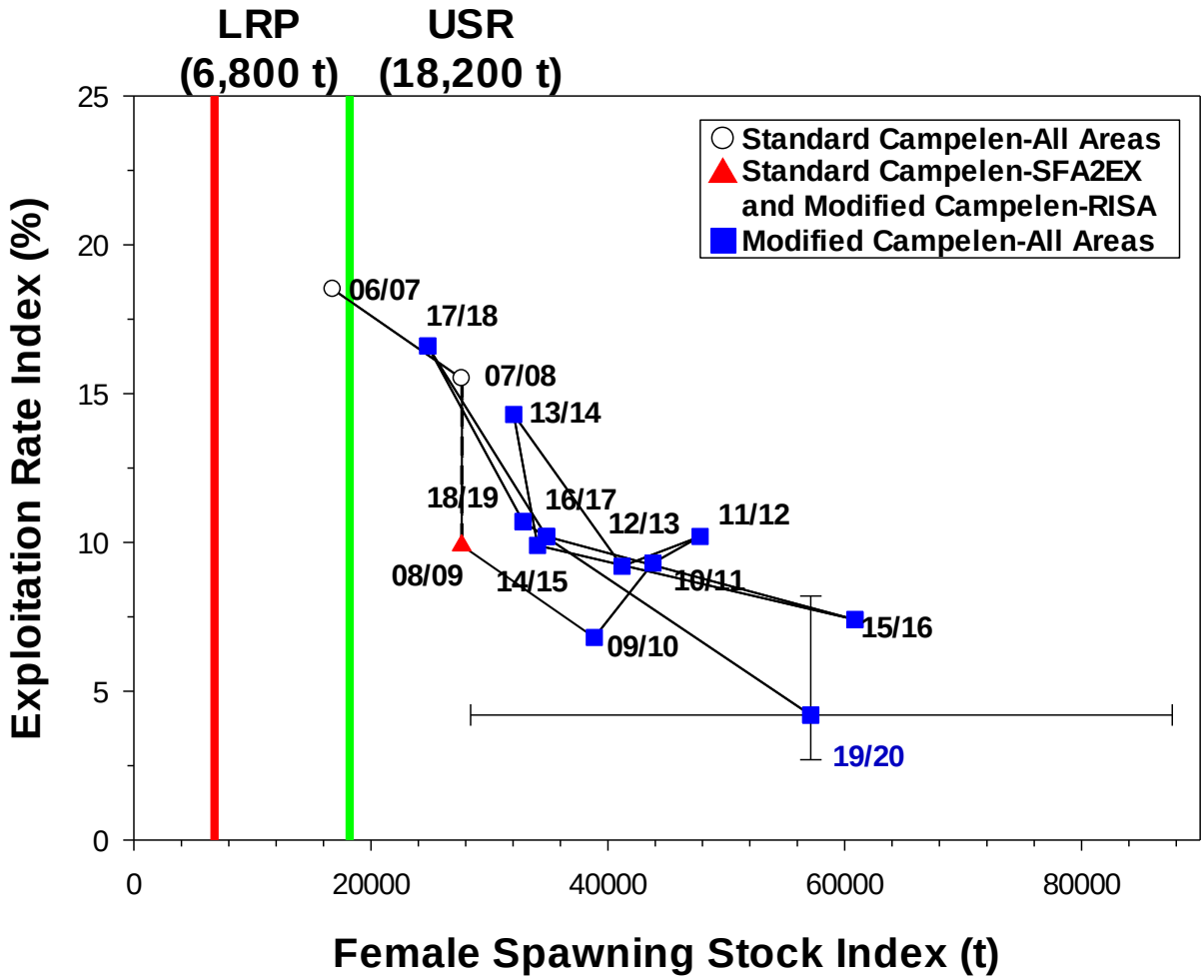

Figure 5. Eastern Assessment Zone trajectory of Pandalus borealis female spawning stock biomass and exploitation rate indices in relation to reference points. USR=Upper Stock Reference and LRP=Limit Reference Point. Error bars are 95% confidence ranges.

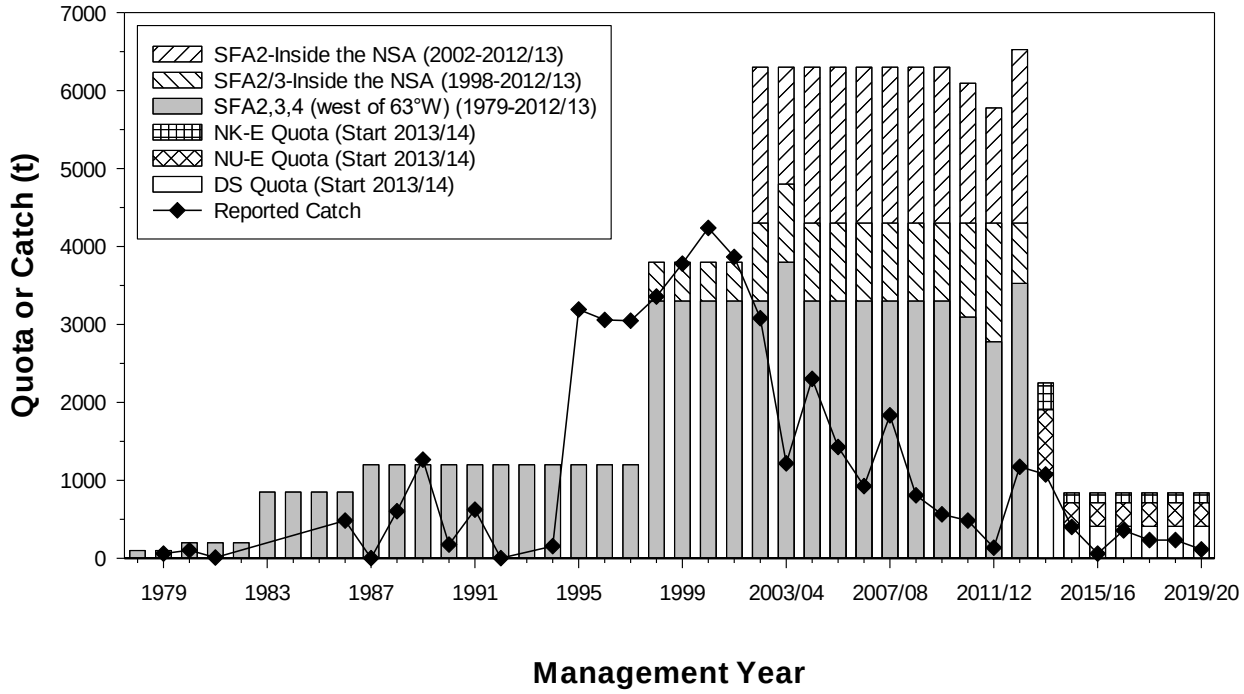

Figure 6. Eastern Assessment Zone Pandalus montagui TAC and catch recorded in the CAQR. Catch based on CAQR as of January 7, 2020. Since fishery is still open the catch is not complete for 2019/20. New management units were implemented for the 2013/14 season.

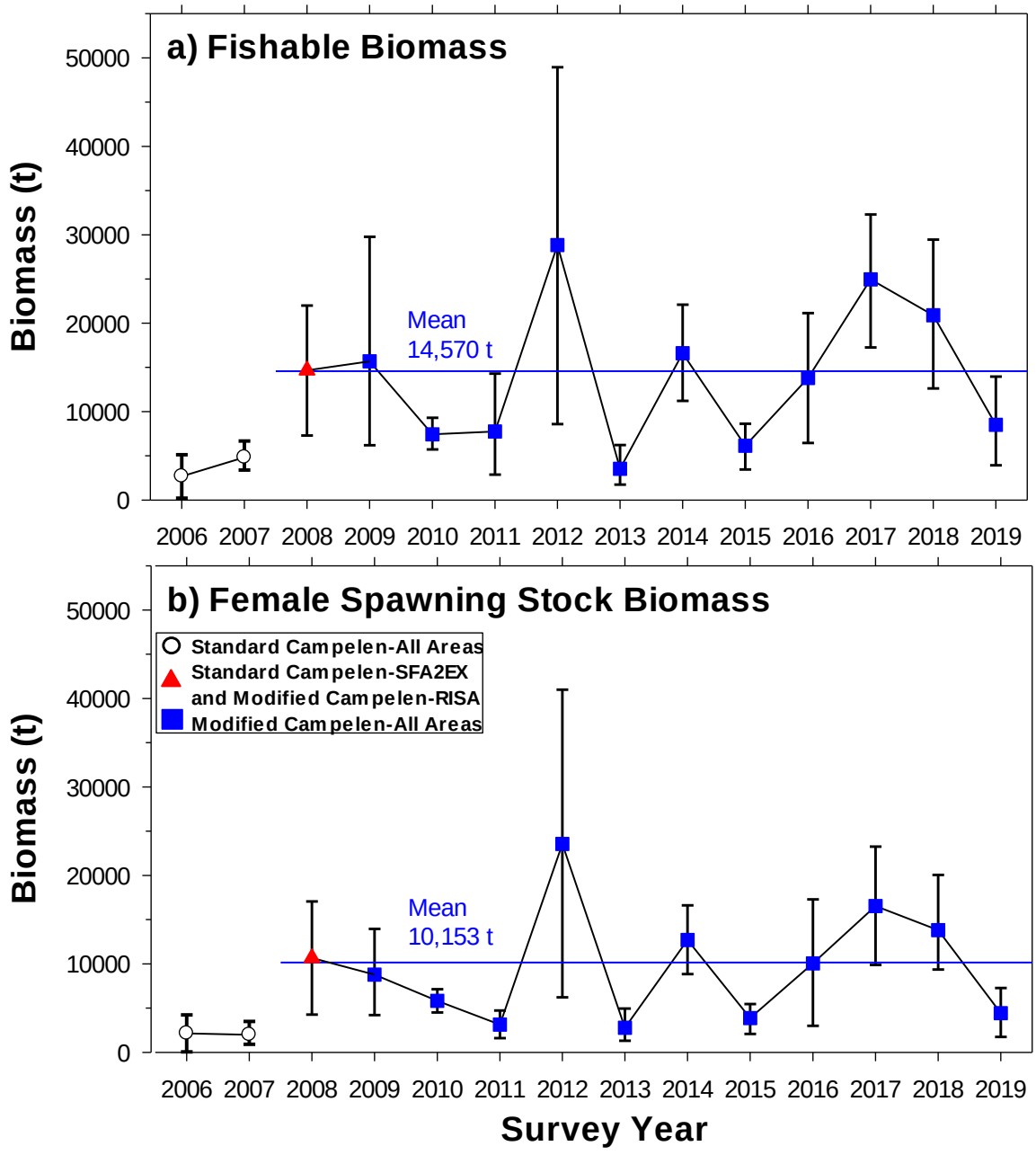

Figure 7. Eastern Assessment Zone Pandalus montagui a) fishable and b) female spawning stock biomass indices for the survey years 2006-2019. Error bars are 95% confidence ranges.

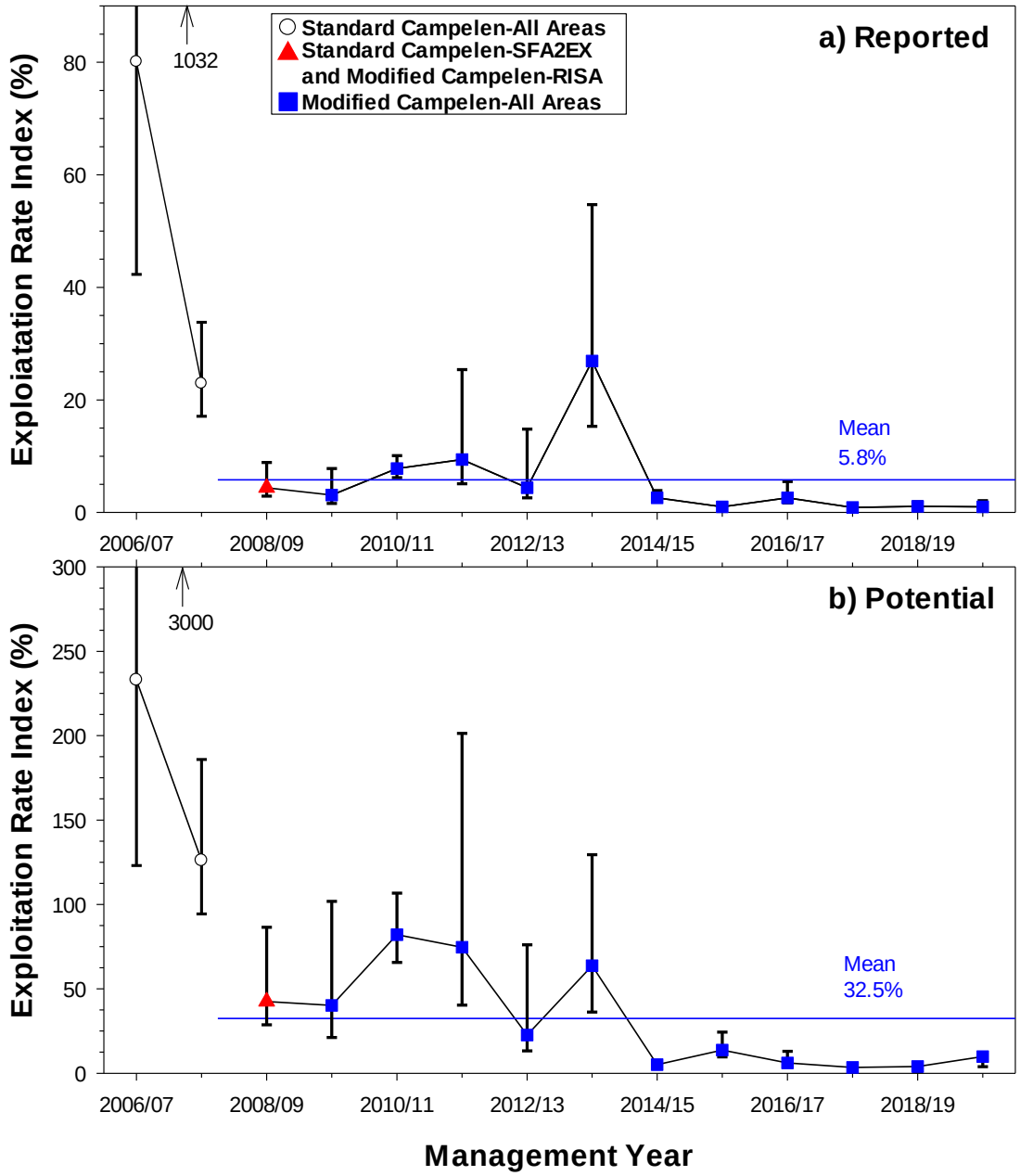

Figure 8. Eastern Assessment Zone Pandalus montagui a) reported and b) potential exploitation rate indices for 2006/07-2019/20. Error bars are 95% confidence ranges.

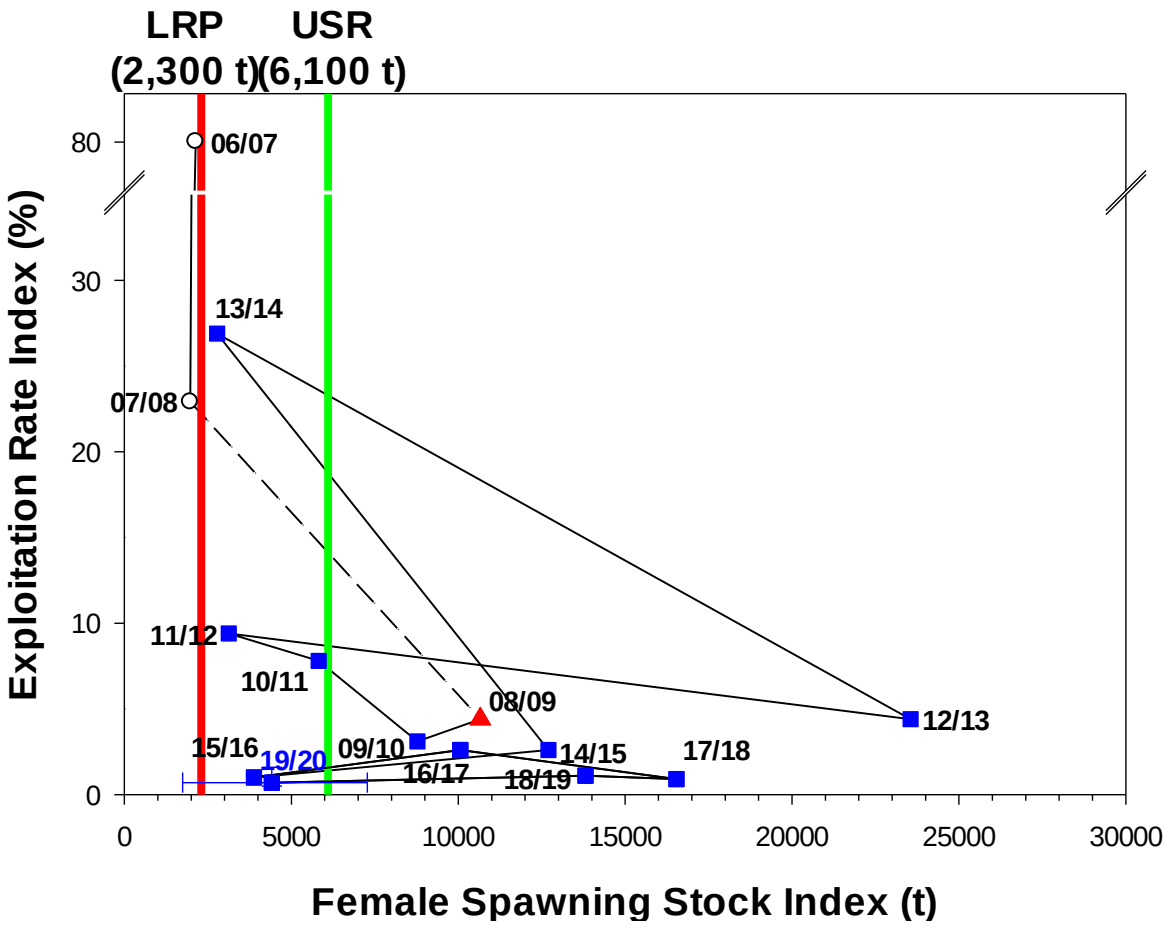

Figure 9. Eastern Assessment Zone trajectory of Pandalus montagui female spawning stock biomass and exploitation rate indices in relation to reference points. USR=Upper Stock Reference and LRP=Limit Reference Point.

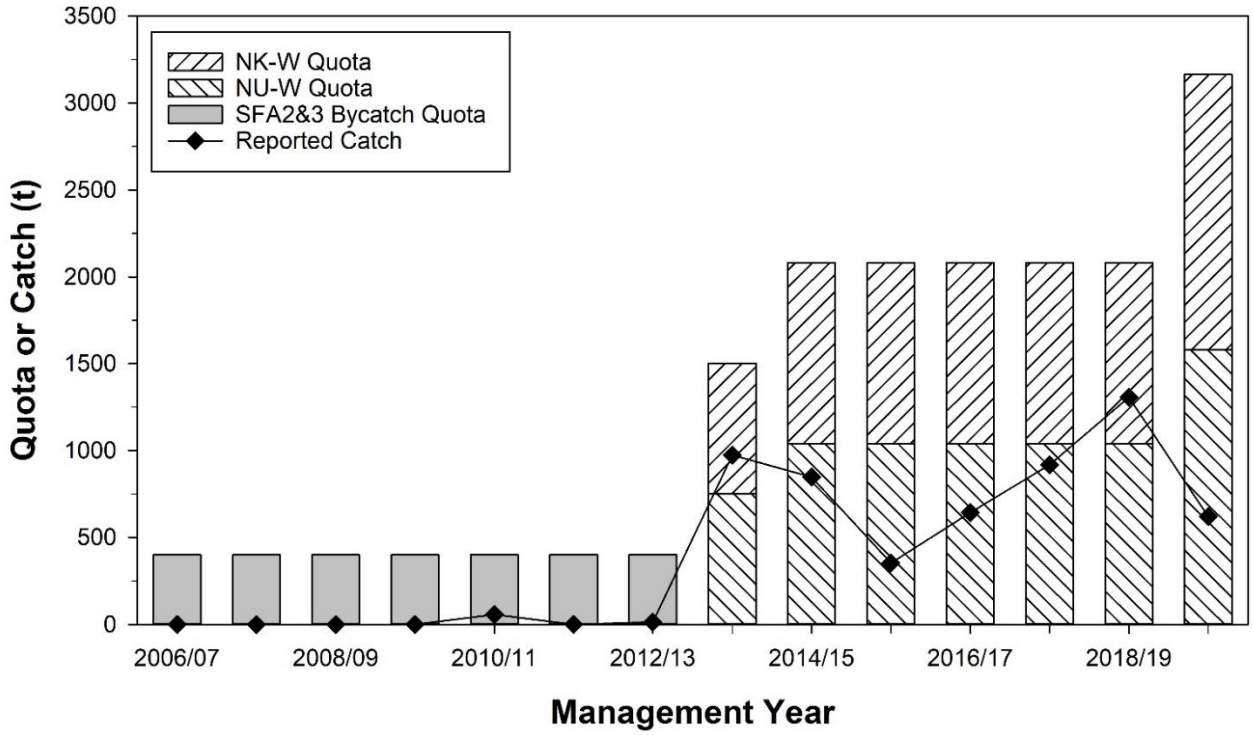

Figure 10. Western Assessment Zone Pandalus borealis TAC and catch recorded in the CAQR. Catch based on CAQR as of January 7, 2020; since the fishery is still open the catch is not complete for 2019/20. New management units were implemented for the 2013/14 season.

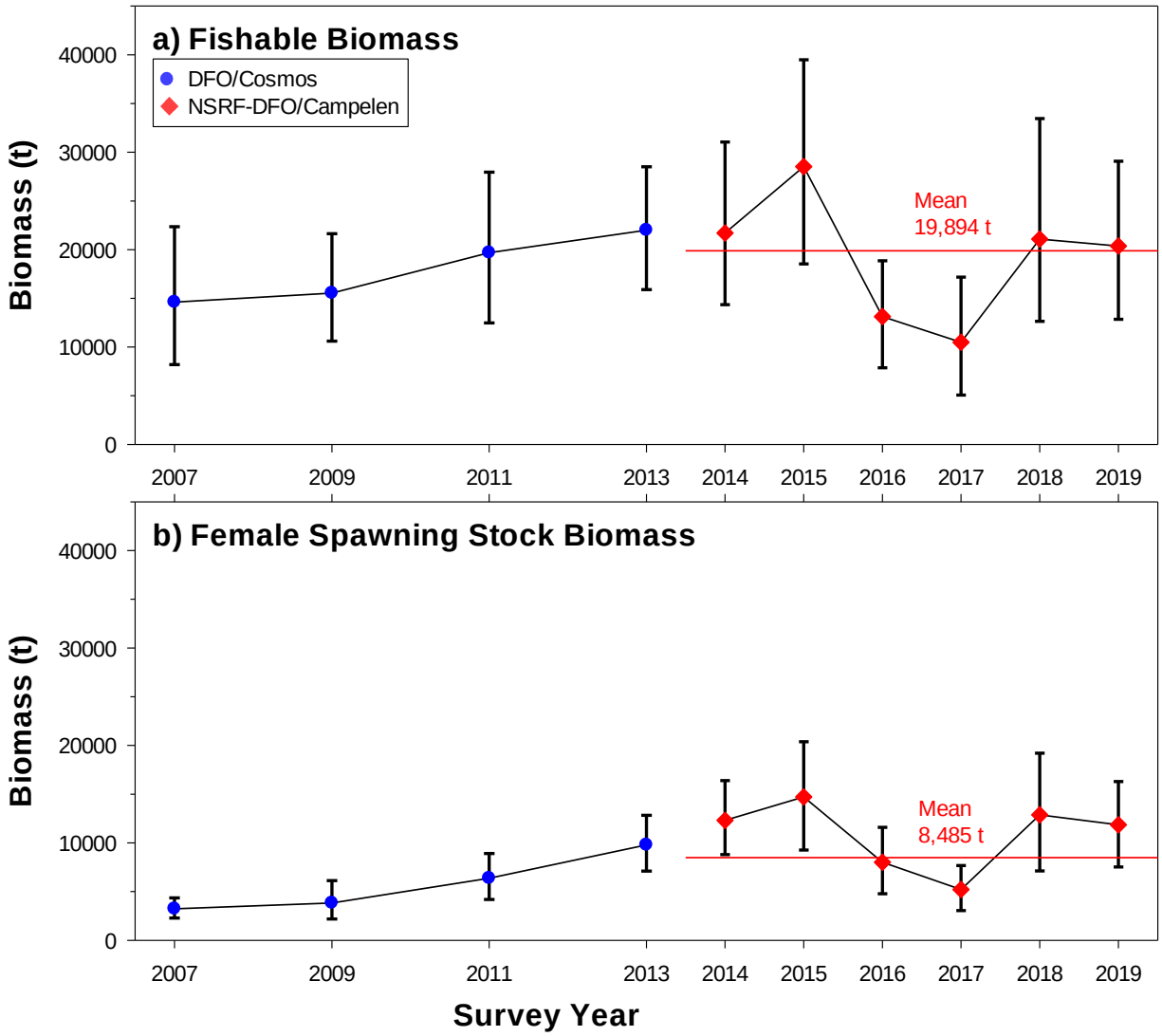

Figure 11. Western Assessment Zone Pandalus borealis, a) fishable biomass and b) female spawning stock biomass indices for the four years of DFO/Cosmos surveys and six years conducted by the NSRF-DFO/Campelen. Biomass indices from the two surveys are not directly comparable. 2014 represents the start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

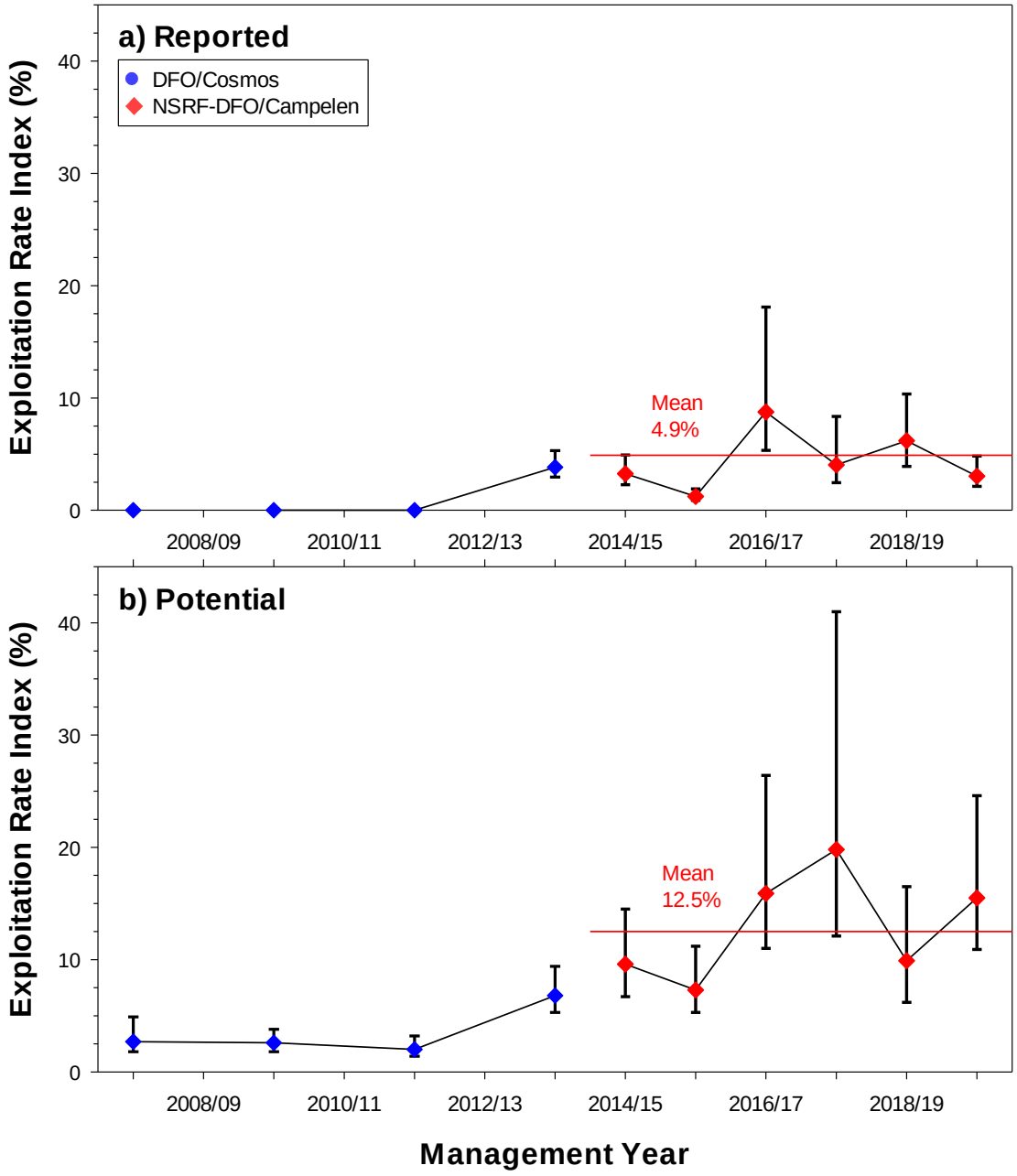

Figure 12. Western Assessment Zone Pandalus borealis a) reported and b) potential exploitation rate indices for the four years of DFO/Cosmos surveys and six years conducted by the NSRF-DFO/Campelen. Exploitation rate indices from the two surveys are not directly comparable. 2014 represents the start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

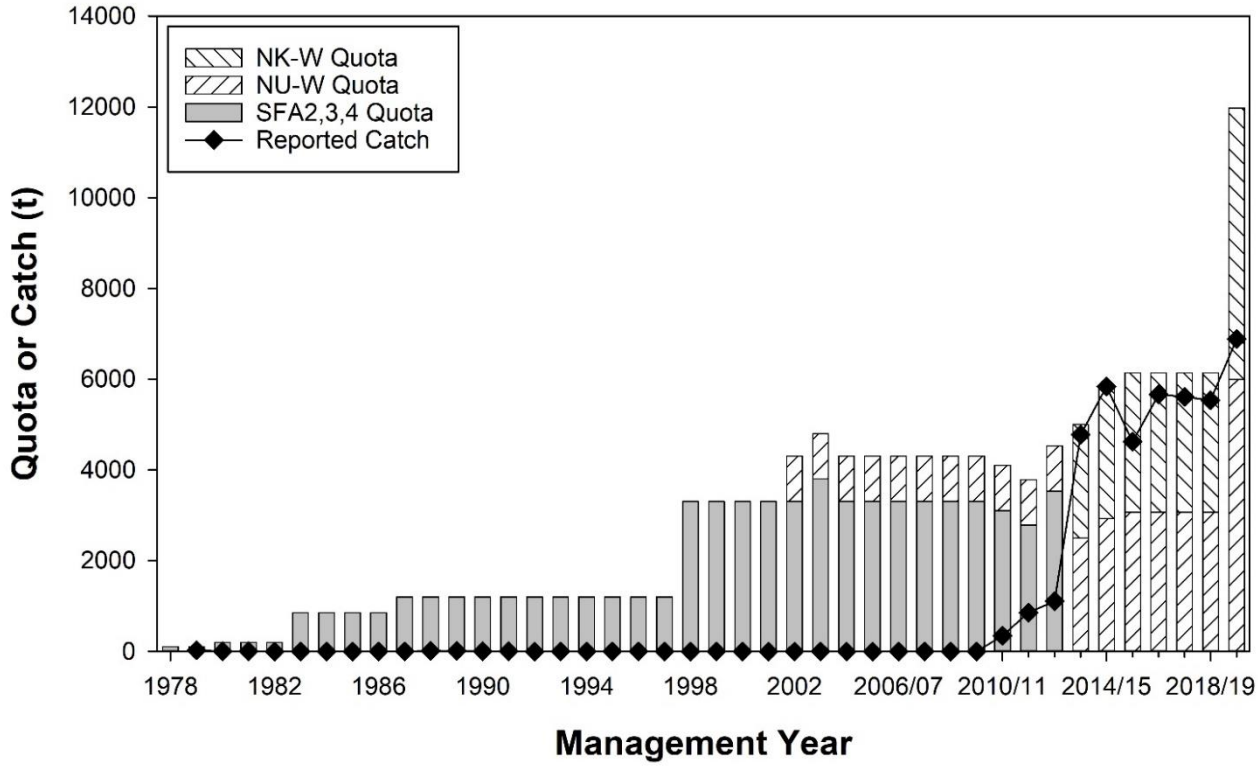

Figure 13. Western Assessment Zone Pandalus montagui TAC and catch recorded in the CAQR. Catch based on CAQR as of January 7, 2020; since fishery is still open the catch is not complete for 2019/20. New management units implemented for the 2013/14 season.

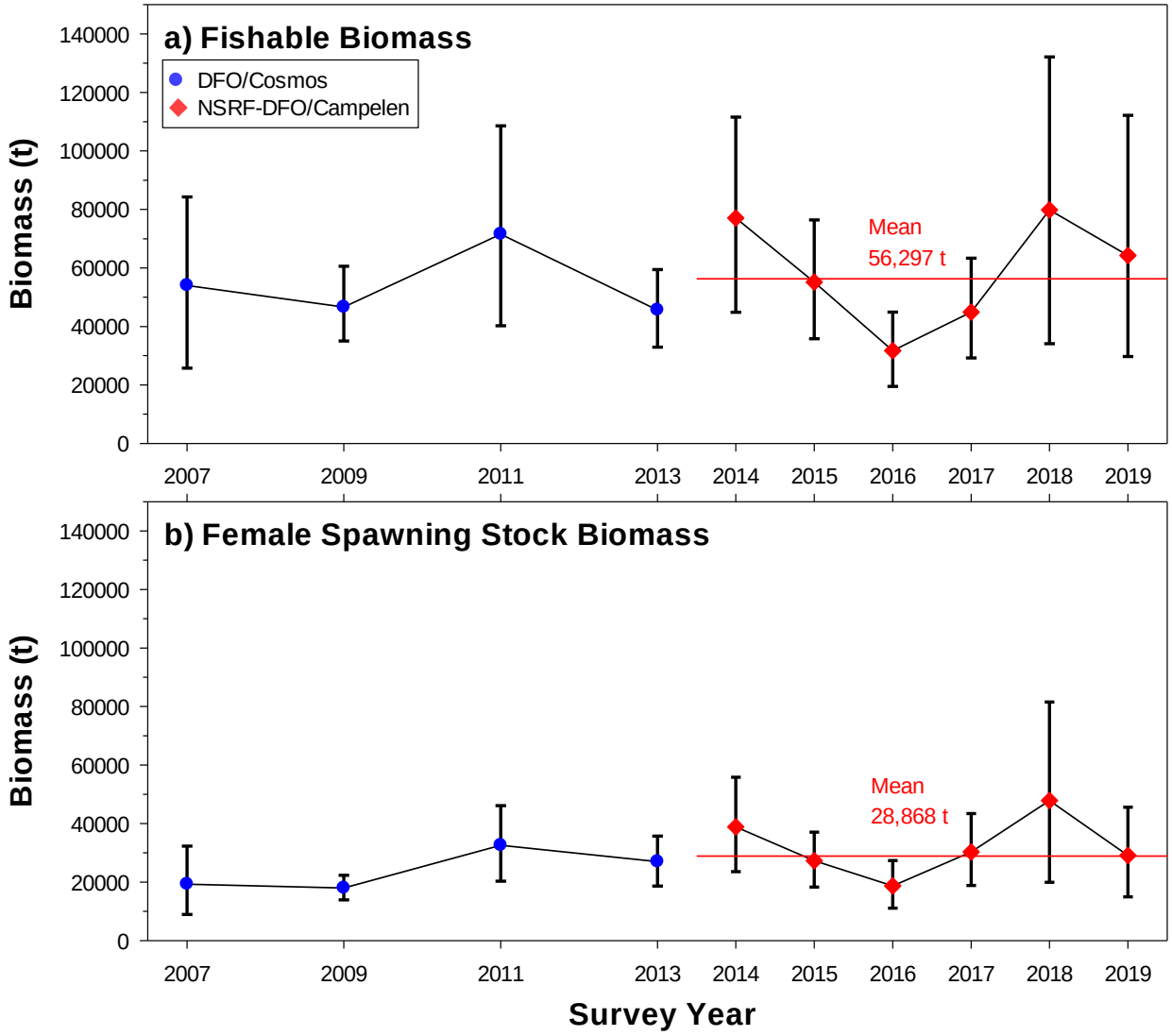

Figure 14. Western Assessment Zone Pandalus montagui, a) fishable biomass and b) female spawning stock biomass indices for the four years of DFO/Cosmos surveys and six years conducted by the NSRF-DFO/Campelen. Biomass indices from the two surveys are not directly comparable. 2014 represents the start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

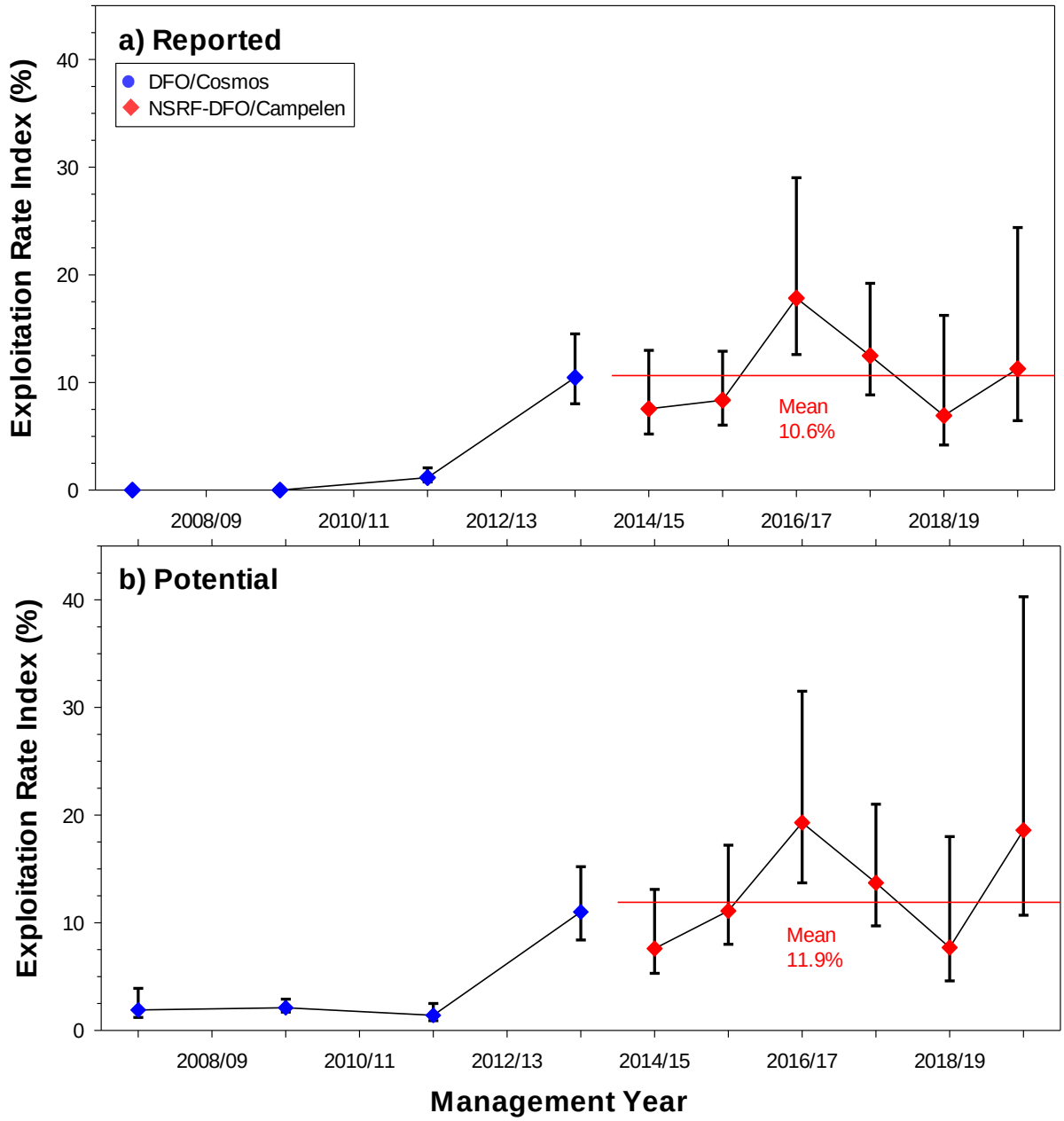

Figure 15. Western Assessment Zone Pandalus montagui a) reported and b) potential exploitation rate indices for the four years of DFO/Cosmos surveys and six years conducted by the NSRF-DFO/Campelen. Exploitation rate indices from the two surveys are not directly comparable. 2014 represents the start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

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