

Review of "Observed currents in the Archipelago Sea"

This manuscript presents a comprehensive observational study of currents in the Archipelago Sea (AS), an extremely complex coastal area in the Baltic Sea with myriad islands and narrow straits. The authors have compiled Acoustic Doppler Current Profiler (ADCP) measurements from 10 locations over roughly two decades of short campaigns - a valuable dataset that fills a longstanding gap in Baltic Sea observations.

The study is highly relevant to Ocean Science, addressing important questions about coastal circulation patterns and extreme currents in an archipelago environment. The manuscript's overall scientific quality is good: the ADCP measurements are well described with appropriate quality control, and the results are presented thoroughly with substantial interpretation. The findings are significant for both scientific understanding and practical applications, as the authors quantify typical current magnitudes and demonstrate the conditions for powerful currents. Notably, the paper identifies local wind as the primary driver of currents but also highlights how basin-scale seiches and local sea-level differences can generate strong flows when local winds are weak or unfavorably oriented. However, the authors' claims would be more convincing if they were better supported by the available observational data or complemented by modeling, which could help clarify the intervariability among parameters. Overall, the manuscript is well structured and written in generally clear language, although the clarity of the writing and the presentation of the figures could be further improved. It represents a useful and original contribution that fits well within the scope of Ocean Science.

General comments

Data Gaps and Seasonal Bias: Some deployments suffered from significant data gaps. For instance, at Fölskär only 35% (or to be corrected?) of near-surface data was obtained due to summertime acoustic issues (implied around lines 117–126). The authors should discuss whether such gaps might bias the analysis of seasonal currents. Do missing summer measurements (e.g., June–July at Fölskär) affect the calculated mean speeds or directional distributions for that location? A brief comment on if and how these data gaps were handled would be useful.

Combining Short Datasets: The study compiles current measurements from multiple short-term campaigns across two decades. While this provides broad coverage, it also raises comparability concerns. The authors acknowledge differences in measurement setups and varying weather during each deployment. It would be helpful if they elaborated on if (and if yes) how they accounted for these differences when comparing sites. The paragraph about unifying all measurements into seasonal statistics (lines 270–275) is not convincing to make such analysis based on Fig 10. Perhaps indicating seasonal data completeness in Fig 10 would help with interpretation of statistics (e.g perhaps other stations with missing winter data could also encounter strong currents).

Persistency Metric Usage: The persistency (P) metric is defined in Section 2.3 (line 165–170) as a

measure of how consistently currents maintain one direction. However, P is mentioned only briefly in the text, mostly through unnecessary numerical statements without further explanation or discussion. It would strengthen the manuscript to report and interpret P values for the different regions. For example, how persistent are the flows in narrow straits versus open areas or southern vs northern AS? Reasons for low P (high or low frequency oscillations) including a short commentary on persistence (perhaps in Section 3 or 5) would give a quantitative sense of directional variability and complement the qualitative descriptions.

Seiche- vs Wind-Driven Flows: A major finding is that about 75% of strong current events align with local wind, while ~25% oppose it due to sea-level gradients (lines 319–322). This is an important result for understanding forcing mechanisms, however this is hard to see from the later analysis of Fig 12-14, therefore all of the conclusions and statements on these figures are a bit vague. Further the authors might consider expanding the discussion on how to predict or identify these sea-level-driven events as the navigation safety is mentioned multiple times. For instance, could a combination of low local wind ($<10 \text{ m s}^{-1}$) and a large Gulf of Finland seiche be a practical indicator of an upcoming current reversal?

Contextualizing Findings: The discussion could better contextualize these results relative to previous knowledge and broader implications. The authors do compare their measurements to past campaigns and models (lines 443–451), noting similar behavior in other straits and agreement with model simulations. It would be worthwhile to explicitly highlight what is *new*. For instance, is this the first direct evidence of $>100 \text{ cm s}^{-1}$ currents in the Archipelago Sea (confirming model predictions)? Do the results alter our understanding of AS circulation, or mainly reinforce existing model expectations? A few sentences synthesizing how this extensive dataset advances knowledge would be valuable. Additionally, since safety of navigation is a motivation (lines 225–226), the authors might comment on how their findings could be used by mariners or somehow integrated into warning systems in the future.

Title could be refined: it is accurate, but overly broad and generic. It doesn't reflect the depth of the analysis or the study's key contributions. A more descriptive and specific title would help the paper stand out and communicate its scientific focus better.

General comment regarding figures:

- Consider adding letters to figures instead of (lower right panel). See the "Figure content guidelines:" in journals' submission guidelines.
- Avoid crowded scatter plots, where the majority (?) data is overplot.

Specific Comments:

- **(line 5):** *"lack of quality ensured measurements"* – This phrasing is odd. It should likely be **"lack of quality-assured measurements"**, since the authors mean there were no previously quality-controlled current observations.

- **(line 13):** *“northern end of the long NE strait”* – The term “NE strait” is used without prior definition. Readers might not know *NE* means north-eastern here. Consider spelling out or referring to it as “the north-eastern strait” for clarity.
- **(line 14):** *“surrounding basing”* – Typo, “**basing**” should be “**basins.**” (e.g., “oscillations in the surrounding basins”).
- **(line 15):** *“non optimal direction related to the straits”* – Awkward phrasing. It would read better to use a hyphen in “non-optimal” and clarify “related to” as “relative to” or “with respect to.”
- **(line 30):** *“using a large network of light ships”* – Consider clarifying “**light ships**” if this is a historical term (lightships). For modern readers, a brief note that these were essentially floating lighthouses used for measurements might help, but this is minor.
- **(line 66):** *“have been largely unrepresented and published before this paper.”* – This seems contradictory. Likely a mistake: perhaps “**unrepresented and unpublished**” was intended.
- **(line 69):** *“inner parts of the AS and concluded that the interactions are extremely complicated due to the heterogeneity of the area.”* – Suggest adding an explanation if possible. It’s understandable, but “extremely complicated” interactions could be elaborated in manuscript, since the reference is a report in non-English and very old one. Perhaps (if available) refer to some recent study which elaborates the “extreme complexity.”
- **(line 76):** *“even 15 m/s SW winds were not able to induce strong currents in this area”* – Perhaps specify “**in that area**” (Lövsjär cross-section) to make it clear you are referring to the specific site studied by Kanarik et al. (2018), not the whole archipelago.
- **(Table 1):** The table of ADCP moorings has some formatting issues.
For example, the second entry “**SVM2S 25 Apr – 25 Aug 2006**” lacks a location name. Is this the Fölsjär measurement (assuming from Fig 2.)? Please ensure each dataset is clearly named (or clearly grouped) in the table for cross-reference.
Also, the note ‘*device changed on XXX*’ should be included as a footnote or placed in an additional column, since the current column is intended specifically for the observation period.
- **(line 125):** **Devise** should perhaps be device.
- **(line 127):** without the technical understanding or description about the technology behind ADCP devices it is hard to understand what are the ‘ensembles’ and ‘solutions’ that ADCP is unable to calculate.
- **(line 131):** The description of data return at Fölsjär is a bit hard to parse. It says only 35% of near-surface measurements were successful above the thermocline. Though I can not conclude from Fig. 2, where the amount of “good data” seems to be significantly higher.
- **(line 133):** *“vertical velocities and thus error velocities were exceptionally high at the bottommost 4 bins.”* – Good that this was caught. The fix (removing bottom four bins) is fine, but maybe mention in the Table 2 or text (perhaps ref ID) which dataset instead of “Norrgrundet second deployment” this concerns, for clarity.
- **(line 150):** *“Continuos simultaneous data of atmospheric pressure from multiple ASW stations...”* – Two issues here. “**Continuos**” is a typo; it should be “**Continuous.**” Also, “**ASW stations**” appears to be a typo for “**AWS stations**” (Automatic Weather Stations). Please correct these to avoid confusion.

- **(line 163):** *"This data is available..."* – Technically, **"data"** is plural. Perhaps say **"These data are available..."** (also at line 147). Consistent plural use would be preferred (e.g., "Data were collected..." rather than "data was").
- **(line 168):** The formula for persistency (P) is presented. Ensure that all symbols (\sum , n , N , u_n , v_n) are properly defined in the text. Currently, *"where u and v are the eastward and northward velocity components..."* is given. Perhaps also clarify that n indexes each observation in the time series and N is the total number of observations, for completeness.
- **(line 172–176):** The definition of four geographic sub-regions is useful. However, it might help to explicitly list which measurement sites belong to each region (perhaps in the caption of Figure 1 or in Section 3.1–3.4 headings or in Tables). Currently the reader must infer from Section 3.1 text which sites are "southern edge." A direct mapping (e.g. on Fig) would improve clarity.
- **(line 185):** *"3.1 Currents in the southern edge of the archipelago"* – Consider capitalizing Archipelago Sea when referring to the region (consistency issue). Also "southern edge" vs "southern part" – just ensure consistency with earlier nameings.
- **(line 186):** *"the occasional halocline and seasonal thermocline divide the water column"* – verb agreement: "divide" should be **"divides"**. Or rephrase the sentence for clarity.
- **(line 206):** *"3.2 Currents inside the archipelago"* – Same naming issue as earlier 3.1 paragraph. Perhaps use **"central archipelago"** to align with the earlier description of Area 2.
- **(line 220)** *"higher persistency at Söderkobb compared to the other two stations are explained by the seasonality of the measurements (Sect. 3.5)."* raises the question of whether this higher persistence is actually due to missing observations during colder periods at Söderkobb, unlike the other stations. It would be helpful to elaborate on this point in Section 3.5 and discuss whether the observed persistence is a statistical artifact resulting from data gaps or a true physical feature. In a similar manner, it would be worthwhile to reassess the rest of the analysis to ensure that patterns attributed to physical processes are not instead influenced by data gaps or seasonal biases.
- **(line 313):** *"reached magnitude up 30 cm s⁻¹ at Norrgrundet"* – Missing a word: **"up to 30 cm/s."**
- **(line 319):** *"There were all together 224 events during c. 30 months..."* – **"all together"** should be **"altogether"** (one word) in this context. Also consider replacing "c. 30" with **"approximately 30"** for clarity (casual readers may not recognize "c." as "circa").
- **(line 327-333):** It seems to be one of the key results. However it is hard to interpret from the Figure 12. As much as I can read from the figure it seems that the strongest northward currents (>100 cm/s) are mainly related to "winds to west" rather than "to north". Same for southward currents where "winds to east" could be related to strong currents. Perhaps some multi-linear regression or clustering technique could be used to make more solid estimates with interrelationships between current speeds, sealevel and wind characteristics. Currently these inter-relationships are a bit vague and almost impossible/controversial to see from the colorful scatter plots.
- **Figure 8.** Add Isokari AWS, if it fits to the region
- **Figure 12.** It is hard to interpret the relationships given in text from the figure. Consider better phrasing, additional annotation - or completely redoing the figure. Too much information makes the reading hard - and even controversial (see previous comment regarding lines 327-333).

Consider focusing only on the key data that effectively delivers the message, rather than including all measurements, which can overwhelm the reader. If, during revision, you find that all data points are indeed necessary, avoid plotting them all on top of each other, as this currently results in displaying only a partial segment at the end of the time series. Additionally, it would be clearer to use a consistent approach to wind direction within a single figure - either 'winds to' or 'winds from' - to avoid confusion, or justify the use of different notation.

(line 334): *“During the strongest current event, with a magnitude of 115 cm s^{-1} on 22 February 2017 (Fig. 13), both the wind and the sea level forcing drove the northward flow...”* – The phrase “sea level forcing” might be unclear. Maybe say “**sea level gradient**” or “**sea-level setup**” to be explicit.

- **(line 336):** *“In addition to external forcing, the narrowness of the channel further amplified the flow (Fig. 8).”* – Here “external forcing” refers to wind and pressure presumably. This is fine, but perhaps specify: “**In addition to wind and sea-level pressure forcing...**” for clarity, since “external” could be interpreted as outside the strait.
- **(line 337):** *“SSE winds with around 20 m/s speed blew for several hours and the sea level was 9 cm higher in Föglö than in Rauma and Hanko”* – It would be clearer as: “**SSE winds of ~20 m/s blew for several hours, and during this time the sea level at Föglö was about 9 cm higher than at Rauma and Hanko...**”. This explicitly states which location had the higher water level.
- **(line 339):** *“The second strongest event, with a magnitude of 104 cm s^{-1} on 28 December 2016 (Fig. 14), followed the sea level gradient over the AS and was formed while the wind was opposing the strong sea level gradient.”* – There is potential confusion with dates (see next comment). Assuming 28 Dec 2016 is correct, the wording “followed the sea level gradient” could be rephrased as “**occurred in response to a sea-level gradient across the AS**” or “**was driven by a sea-level difference across the AS, with wind blowing in the opposite direction.**”
- **(Fig. 14 caption):** There is a **discrepancy in dates for the second strongest event**. The text says 28 December 2016, but the Figure 14 caption refers to “(29 Jan 2016)” – which seems incorrect. **This is confusing and likely an error.** Please clarify the timeline of events:
- **(line 342):** *“wind speed had degreased below 10 m s^{-1} .”* – “**degreased**” is a typo; should be “**decreased.**”
- **(line 344-346):** *“winds packed water to the end of the gulf on 24 December 2017 (seiche). Once sea level simultaneously fell at the Gulf of Bothnia on 28 Dec, the simultaneous seiche at the Gulf of Finland created such a strong gradient over the AS that it was able to oppose the weakened local wind.”* – The dates here are likely wrong given context. Assuming it should be late 2016. Consider rephrasing eg. “winds had piled up water at the head of the Gulf of Finland on 24 Dec 2016, initiating a seiche. By 28 Dec, sea level in the Gulf of Bothnia dropped, and the resulting seiche oscillation in the Gulf of Finland created a strong sea-level gradient across the AS, one that was able to drive currents against the now-weakened local wind.” This separates the two basins’ contributions and uses correct timing.
- **(line 354):** *“compared to the SW corned (Föglö).”* – “**corned**” is a typo; should be “**corner.**”
- **(line 355-358):** *“opposing the sea level gradient to the wind direction only weakens the effect of local winds, whereas currents still follow the direction of the winds. During storm Toini on 11 January 2017 (Figure A2), the winds... The maximum currents measures were 99 cm s^{-1} , being*

the third strongest event and had the longest lasting duration of currents over 40 cm s⁻¹ (35 h)."
Consider rephrasing and grammar improvements. Instead of "currents measures" "current was".

- **(line 364):** *"the currents did not begin to follow the sea level gradients before the wind speeds dropped below 10 m s⁻¹."* – Perhaps use **"until"** instead of **"before"** here.
- **(line 370):** Once again referring to Fig. 12 and pointing to 'dark green' wind speeds relation to current speed is hard to follow from figure.
- **(line 379):** *"Continuous atmospheric pressure was only available from 2007 onwards (Sect. 2.2)."*
– Minor phrasing issue: add **"data were"** after "pressure" for clarity.
- **(line 382):** *"Three-hourly measurements from 1991 to 2020 show that the mean wind speed is 7.5 m s⁻¹ in Utö and 6.9 m s⁻¹ in Isokari, and 99%, respectively, being 18 m s⁻¹ and 16 m s⁻¹."* – The part after the comma is confusing. It appears to refer to the 99th percentile wind speeds, which could be used for clarity in further text as well (eg **and the 99th percentile wind...**).
- **(line 404):** *"the event on 29 December 2016 "* Correct the date if needed.
- **(line 417):** *"about 7 times the distance than between Utö and Isokari."* – Should be **"seven times the distance between Utö and Isokari."** (drop "than").
- **(line 485):** *"...shows that neither of these forcings grows strong enough...."*
Maybe change **"forcings grows"** to **"forcing becomes"** or **"none of these forcings is strong enough to induce currents as large as wind can."** Minor grammar.
- **(line 487):** *"23 m s⁻¹ winds could be estimated to include currents well above 50 cm s⁻¹."* – perhaps use **"induce currents"** or **"generate currents"** instead of **"include"**.
- **(line 488):** *"As we for the first time have such a large data set of measured currents from the AS, we were able to catch extreme current speeds..."* – The sentence has awkward word order and mismatched verb tenses, making it unclear and grammatically incorrect. Consider rewriting the sentence.
- **(line 490):** *"Rantanen et al. (2024) has shown"* – **"has"** should be **"have"** (plural verb for "et al.").
- **(line 498):** *"Measurements in the AS can be divided into two types based on current magnitudes: more open sea areas with a mean surface layer magnitude of around 8 cm s⁻¹ and narrow long straits with mean surface magnitudes of around 14 cm s⁻¹."* – Clear summary, but perhaps adding **"surface layer current"** would increase readability.
- **(line 502):** *"the measurement values were below 10 to 20 cm and 99% of the values were around half of the maxima."* – Add **"per second"** after "10 to 20 cm" for units consistency (assuming "cm" alone is a typo and should be cm/s).
- **(line 505):** *"whereas in the southern most Utö stations...."*
"southern most" should be **"southernmost"** (one word).
- **Figure A1 & A2 captions:** Both start with **"Time series"** descriptions. In Figure A2's caption it reads **"Time series the third strongest event..."** – add **"of the"**. Similarly ensure Fig. 13 and 14 captions say **"Time series of the...event"** for grammatical completeness. These are minor but noticeable errors in figure captions.
- **(line 528):** *"provided expertise and incite to the conclusions from their area of expertise."* – perhaps author meant **"insight"** instead of **"incite"** :)