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Defining estuarine squeeze: The loss of upper estuarine transitional zones against in-channel barriers through saline intrusion

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ABSTRACT

Here we define, for the first time, the concept of estuarine squeeze and lay out recommendations for the consistent use of terminology for this new but critical research area. Climate and catchment-driven reductions in river flow together with rising sea levels are increasing estuarine salinities and driving saltwater into upper estuarine zones. This saline intrusion is exacerbated in regions where land level is falling (i.e. relative sea level rise) and in catchments subject to high freshwater demand and water regulation, which reduces river flow. In unmodified systems, many estuaries would naturally migrate inland in response to sea level rise. However, estuaries are some of the most anthropogenically impacted ecosystems in the world, being settlement and development hubs due to the ecosystem services they provide. To protect these assets, many estuaries have man-made in-channel barriers (such as dams, weirs and sluices) at their inland tidal limits, a trend that is likely to continue in the future to protect against the impacts of climate change. As sea levels rise and river flows reduce, saltwater will move further inland. This increasing saline intrusion will be most detrimental for upper estuarine, low salinity (oligohaline) and tidal freshwater zones, which will progressively become 'squeezed out' against these barriers. We have termed this concept 'estuarine squeeze' and define this as 'the progressive loss of extent of upper estuarine tidal freshwater and oligohaline zones against in-channel man-made barriers through saline intrusion and increasing salinities driven by relative sea level rise and/or reductions in river flow'. A lack of research into the structure and functioning of tidal freshwater zones in particular means that the impact of their reduction and/or loss on the wider estuary is unknown. However, there are indications that these zones may play a key role in estuarine biogeochemical cycling, habitat provision, primary and secondary production, food-web functioning, and the provision of trophic subsidies to the brackish estuary and coastal zone. Loss and/or reduction of these zones through estuarine squeeze may therefore result in a net loss of function, with critical implications for the ability of estuaries to continue to provide key ecosystem services into the future.

1. Introduction

Many estuaries exhibit a gradient of salinity from fully marine (euhaline) at the estuary mouth, through to tidal freshwater at the upper tidal limits (Fig. 1) (Elliott and McLusky, 2002). This salinity gradient is determined by both tidal and fluvial dynamics, and so varies on daily (tidal cycle and freshwater pulses), weekly (spring-neap tide) and monthly (lunar phases and seasonal river flow) cycles (Yang et al., 2015). The tidal limit and the inland extent of saltwater are predominantly determined by the relative strengths of these opposing forces; freshwater river flow downstream and tidal forcing upstream (Dyer, 1997). Rising sea levels and/or reduced river flows are resulting in the inland extension of the tidal limit, increasing estuarine salinities with saltwater entering previously tidal freshwater zones (TFZ) (Little et al., 2022), putting some freshwater resources at risk (Reid et al., 2019; Wang and Hong, 2021; Wu et al., 2021). In unmodified natural systems, the response of many estuaries to these changes would be to naturally migrate inland (Fig. 2) (Osland et al., 2022). However, many estuaries are bounded at their upper tidal limits by man-made barriers such as dams, weirs and sluice gates (Figueroa et al., 2022). By blocking the inland ingress of the tide in this way, upper estuarine zones will be progressively squeezed out as salinities increase (see Little et al., 2022)

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(Fig. 2). Here we propose the term estuarine squeeze, as a new concept for the squeezing out of upper estuarine transitional zones against in-channel man-made barriers through increasing salinities. Estuarine squeeze is already occurring but will increase in frequency and significance in the face of changing climate and sea level projections in addition to increasing coastal population growth and coastal hardening (Floerl et al., 2021; Little et al., 2022).

Estuarine squeeze can be considered a related process to coastal squeeze, which is the well documented loss of intertidal habitats in front of littoral man-made barriers, such as sea walls and levees, as sea levels rise (Pontee et al., 2022). In estuaries, the loss of intertidal habitats within the TFZ (i.e. tidal freshwater wetlands) to saline intrusion in this way has become the focus of recent research attention (e.g. Borchert et al., 2018; Colombano et al., 2021; Rullens et al., 2022; Urlich and Hodder-Swain, 2022). However coastal squeeze is not associated with in-channel salinity dynamics in the upper estuary (Fig. 2). We therefore propose the term estuarine squeeze to identify this separate longitudinal subtidal, rather than lateral intertidal, process. Similar to coastal squeeze, hard man-made barriers, in this case in-channel barriers such as weirs, sluices and dams, at the top of estuaries act to block the natural landward migration of the estuarine transition in response to sea level rise and reductions in river flow. This results in the squeezing out of the uppermost estuarine zones. The low salinity oligohaline and tidal freshwater zones are most at risk through loss or reduction of their extents (Fig. 2).

Tidal freshwater zones are located at the top of the estuarine transition (Fig. 1) Elliott and McLusky, 2002). The top of the TFZ (the Normal Tidal Limit; NTL) marks the inland boundary of the estuary (as defined by Dionne (1963), in Fairbridge (1980)). These subtidal zones are freshwater (salinities of <0.5) but subject to tidal action, existing beyond the limit of saline intrusion (Fig. 1) McLusky, 1994; Odum, 1988; Schuhardt et al., 1993; Little et al., 2022). They are especially prevalent in mesotidal (1–4 m) and macrotidal (>4 m) estuaries subject to high river flow (e.g., Little, 2012; Muylaert and Sabbe, 1999; Schuchardt and Schirmer, 1991). Tidal freshwater zones are found worldwide, but appear particularly integral to estuaries in Northern and Western Europe, Spain and Portugal, the Eastern United States and South America and Eastern Australia and China, where they can constitute a substantial proportion of the estuarine ecosystem (Ensign and Noe, 2018; O'Connor et al., 2022). However, TFZ's have rarely been studied or mapped (but see Schuhardt et al., 1993; Simenstad et al., 2011), particularly in the southern hemisphere, so are likely to be much more ubiquitous than is currently known (O'Connor et al., 2022; Vieillard et al., 2020).

In contrast to the brackish sections of an estuary, our understanding of the structure and function of the TFZ is limited (Muylaert et al., 2005), being routinely omitted from both fluvial and estuarine research owing to its tidal influence, and presence of freshwater fauna, respectively (e.g. Attrill et al., 1996; Odum, 1988; Rundle et al., 1998; Schuhardt et al., 1993; Sousa et al., 2005). There is however a growing body of evidence to suggest that the specific environmental conditions and ecology of the TFZ, and its role in linking terrestrial, river and estuarine systems, mean that these unique zones support distinctive and productive communities and play an important role in the functioning of the estuarine ecosystem as a whole (Lehman, 2007; Little et al., 2022; O'Connor et al., 2022; Schuhardt et al., 1993; Williams and Williams, 1998; Xu et al., 2021). The loss or reduction of these zones through estuarine squeeze may therefore result in a net loss of function, with critical implications for the ability of estuaries to continue to provide key ecosystem services into the future (Ensign and Noe, 2018; Little et al., 2022). This is an issue of growing concern, particularly for the heavily modified estuaries of northern Europe (Little et al., 2017b; van Puijenbroek et al., 2019). Globally, many estuaries have such barriers in place upstream of the current saline intrusion limit (Pietkiewicz et al., unpublished data), and thus face the future reduction or loss of these zones in response to climate and other human-driven impacts such as unsustainable catchment activities.

This short communication is the first time the concept of 'estuarine squeeze' has been defined in the literature, having, as far as we are aware, previously only been mentioned in Little et al. (2022). However, in recent years, studies investigating increasing salinities in estuaries have proliferated, due in part to the visible effects of the consequences of reductions in river flow due to catchment and climatic changes (e.g. Chen et al., 2020; Dai et al., 2011; Garces-Vargas et al., 2020; He et al., 2018; Park et al., 2022; Pereira et al., 2022; Qiu and Zhu, 2013; Rice et al., 2012; Rodrigues et al., 2019; Serrano et al., 2020; Shirazi et al., 2019; Wu et al., 2021; Yang et al., 2015). Sea-level rise, climate change and human modification of river and estuarine systems are only going to

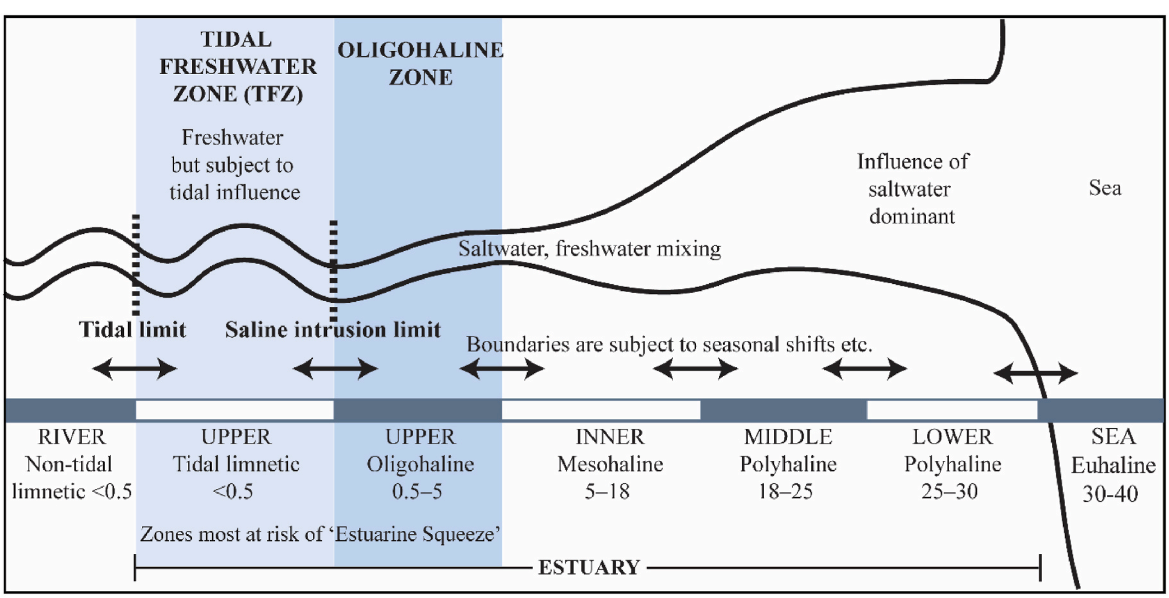

Fig. 1. An example of an unbounded temperate estuary, divided into zones as classified by McLusky (1994), based on the definition by Dionne (1963), in Fairbridge (1980) and the salinity zones of the Venice System (Anonymous, 1958). Special focus is given to the zones most at risk of estuarine squeeze; the tidal freshwater zone and oligohaline zone (shaded in blue). Schematic modified from Little et al. (2022) and Park (1999). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

intensify (Little et al., 2017a), resulting in increased saline intrusion and subsequent squeezing of the upper estuary. As such, we see this as a new and critical research area which merits its own definition and requires the use of a consistent terminology within the scientific literature to provide clarity and ensure that key literature is not missed in systematic reviews on the subject.

1.1. Definitions and terminology

Within the literature a number of terms have been used to describe the inland movement of saltwater into the upper estuary. The most commonly used term is saline intrusion, however other terms such as incursion, inundation and penetration have been used in order to distinguish between surface and groundwater processes. Saline intrusion is a well-established term for the movement of saltwater into freshwater aquifer systems through groundwaters and is associated with a significant body of literature. Whilst it might be preferable to use a different term (such as saline incursion) to distinguish between surface and groundwater process, saline intrusion may already be too widely used to designate a different specific term and is the reason it is used here.

We hereby propose the following terminology and definitions. We define 'Estuarine Squeeze' as:

The progressive loss of extent of upper estuarine tidal freshwater and oligohaline zones against in-channel man-made barriers through saline intrusion and increasing salinities driven by relative sea level rise and/or reductions in river flow.

The cause of 'Estuarine Squeeze' is saline intrusion into the upper estuary. In this context we define 'saline intrusion' as:

The process of increasing tidal driven inland ingress of saltwater into estuaries as a result of relative sea level rise and/or reductions in freshwater river flow.

2. Saline intrusion and estuarine squeeze as a 21st century problem

Increasing saline intrusion into estuaries is driven by relative sea level rise (RSLR) and reductions in river flow through unsustainable catchment activities and climate changes, but is exacerbated by human modifications to the estuary channel (Khojasteh et al., 2021). Saline intrusion is chronic (i.e. a persistent increase in salinity over time), but also episodic, with saline pulse events experienced during extreme hydrological event (EHE) drought conditions and extreme sea level events (Prandle and Lane, 2015; Wu et al., 2021).

Global sea levels are predicted to rise between 0.63 and 1.01 m by 2100 under the highest GHG emissions scenario (IPCC, 2021), although instabilities of the Greenland and Antarctic ice sheets could contribute more than one additional metre of sea level rise to this total (Oppenheimer et al., 2019). The most significant effects of this will occur where land levels are sinking (e.g. through glacio-isostatic adjustment and geological subsidence; Shennan and Horton, 2002), thereby contributing to increases in sea levels relative to the land (Nicholls and Klein, 2005). Extreme sea level events, such as storm surges, are projected to intensify with climate change. When combined with RSLR, high tides and low river flows, these will result in saline intrusion pulse events reaching far inland (Church et al., 2013; De Dominicis et al., 2020; Li et al., 2022; Talke and Jay, 2020; Tully et al., 2019). The responses of estuaries to RSLR will be complex and context dependent (Khojasteh et al., 2021), however it is projected that increases in saline intrusion will be most extreme in low gradient (e.g. coastal plain), shallow estuaries with depths <10m (Krvavica and Ružić, 2020; Leuven et al., 2019; Mulamba et al., 2019; Prandle and Lane, 2015; Williamson and Guinder, 2021). In estuaries that are heavily modified, saline intrusion is exacerbated by human activities such as channelisation (i.e. the deepening and narrowing of estuarine channels and removal of flood storage areas) for navigation and flood defence, which work to amplify and propagate

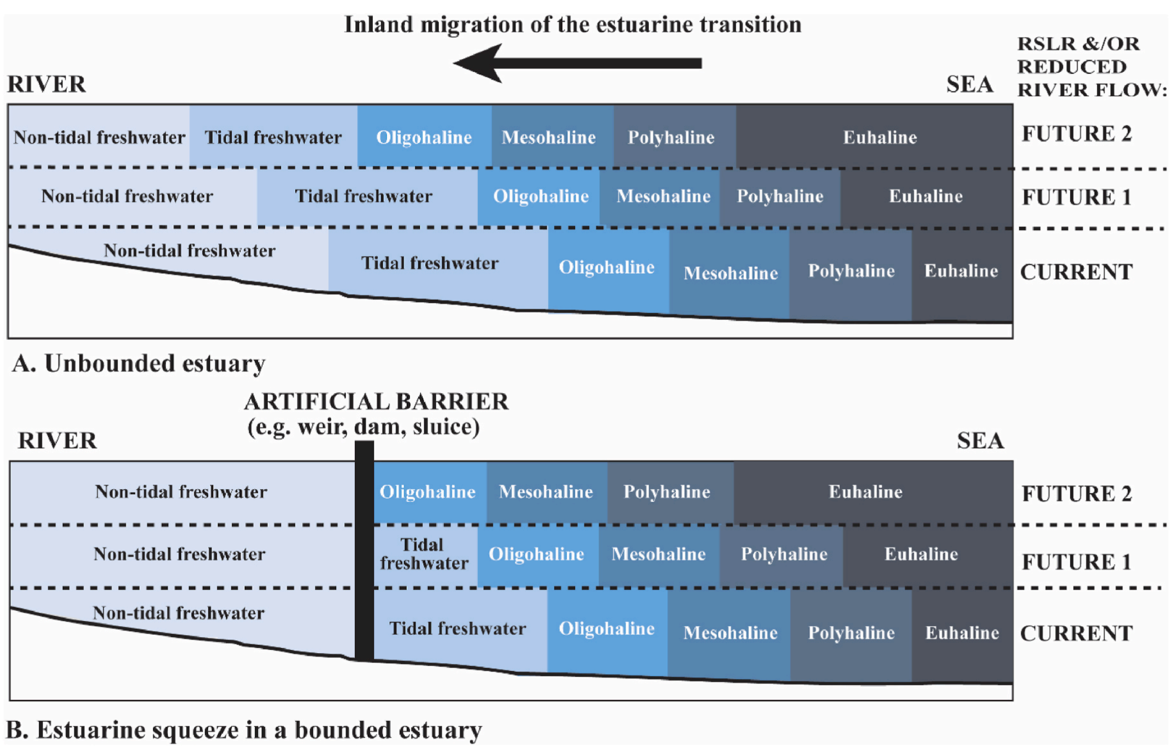

Fig. 2. Estuarine squeeze schematic showing hypothetical spatial changes in estuarine salinity zones (based on the Venice system) through time in an A) unbounded and B) bounded estuary in response to saline intrusion driven by relative sea level rise (RSLR) and/or decreased river flow. A) In an unbounded 'natural' system the estuarine transition can migrate inland. B) In a bounded system, an artificial barrier prevents inland migration, resulting in the squeezing out of upper estuarine zones. In Future 1 (B) the tidal freshwater zone is experiencing estuarine squeeze. In Future 2 (B) the tidal freshwater zone has been lost and the oligohaline zone is subject to squeeze. Schematic modified from Little et al. (2022).

the tidal wave upstream (Eidam et al., 2022; Familkhalili et al., 2020; Talke et al., 2021; Wu et al., 2021).

Where river flows are reduced through climate (i.e. precipitation and temperature) and/or catchment-driven changes (e.g. in land use, water diversion, storage and abstraction), the degree of saline intrusion has been shown to increase (Dai et al., 2011; He et al., 2018; Park et al., 2022; Qiu and Zhu, 2013; Rice et al., 2012; Wu et al., 2021; Yang et al., 2015). Between 1880 and 2012 global temperatures increased by 0.85°C which led to a reduction in estuarine river flow due to greater evaporation and evapotranspiration rates in catchments (IPCC, 2014; Nijssen et al., 2001). In the absence of large reductions in greenhouse gas emissions, global warming of 1.5°C and 2°C is likely to be exceeded during the 21st century, further reducing estuarine river flow (IPCC, 2021).

Future climate projections for river flow vary globally (i.e. Bricheno et al., 2021; Shi et al., 2019) but are projected to become more variable over most land regions within seasons and from year to year, with extreme hydrological events (floods and droughts) predicted to become more severe and frequent (IPCC, 2021). In Europe, for example, warmer, wetter winters and hotter, drier summers with more frequent, high intensity extreme weather events are predicted (Arnell, 2003; Christierson et al., 2012; Vautard et al., 2014). Globally, rivers predominantly show downward trends in flow (e.g. in North America and Africa) with a few upward trends (e.g. in Europe; Shi et al., 2019) albeit with more frequent seasonal high and low flow periods (Murphy et al., 2009). A warming climate combined with increased human demand for water (for domestic, agricultural and urban use) will deplete river flows further (Chilton et al., 2021). Interception, diversion and storage of freshwater in the catchment and river basin (e.g. through the construction of reservoirs) is likely to increase to ensure reliable supply (Broadley et al., 2022) and it is projected that increased groundwater abstraction may considerably exceed any future effects of climate change on river flow regimes (Vörösmarty et al., 2010). Catchment water storage will further change the timing and magnitude of flow, increasing saline intrusion when water is withheld (Chilton et al., 2021; Herbert et al., 2015). Globally, very few rivers retain their natural flow regimes due to fragmentation by dams and water regulation in the catchment (Bunn et al., 2014; Nijssen et al., 2001; van Puijenbroek et al., 2019; Vörösmarty et al., 2010), reducing freshwater flows into estuaries (Herbert et al., 2015; Reid et al., 2019; Vörösmarty and Sahagian, 2000). For example, when coinciding with drought events, the operation of the Three Gorges Reservoir in the Yangtze river has resulted in severe saltwater intrusion in the Changjiang Estuary (Dai et al., 2011). In strongly tidal estuaries, changing river flows of 25% (either increase or decrease) has been shown to have significant effects on both vertical mixing and saline intrusion extent (Prandle and Lane, 2015).

In estuaries, barrages, weirs, dams and sluice gates have been constructed to regulate tidal flows in order to secure upstream freshwater storage and abstraction, prevent saline intrusion and to enable land reclamation, navigation, flood protection and tidal energy production (John et al., 2022; Sin and Lee, 2020; Zhu et al., 2017). These in-stream barriers are abundant in estuaries in Northern and Western Europe (Díez-Minguito et al., 2014; Pietkiewicz et al., unpublished data; Traini et al., 2015; Verhelst et al., 2018), North America (van Proosdij et al., 2009), Southeast Asia (Lee et al., 2011; Zhu et al., 2017) and Australia (Williams and Watford, 1997), although not all at the tidal limits. In New South Wales, Australia, more than 4000 impediments to tidal flow have been identified along the coastline (Williams and Watford, 1997), and in China around 300 sluice gates have been constructed within estuaries (Zhu et al., 2017). Whilst a few studies have investigated the significant impacts of barriers on estuarine hydrodynamics, sedimentation, geochemistry and migratory fish passage (Figueroa et al., 2020; Figueroa et al., 2022; Wang et al., 2022; Verhelst et al., 2018 and references therein), none have approached this subject in terms of estuarine squeeze. An analysis of English estuaries, using river obstacles data (Environment Agency, 2021), shows that 57% are bounded at their upper limits, making them susceptible to estuarine squeeze (Pietkiewicz et al., unpublished data). The upper estuarine tidal freshwater and oligohaline zones of a number of systems (e.g. the estuaries of the Tees, Mersey and Tyne) have already been squeezed out, with saltwater intruding up to their artificial barriers (Pietkiewicz et al., unpublished data; Carroll et al., 2009; Wright and Worrall, 2001).

Coasts and estuaries are becoming increasingly urbanised due to population growth and coastward migration (Neumann et al., 2015; Little et al., 2017a). This, combined with the threats of RSLR, increasing storminess and the seasonal intensification of rainfall means that estuaries are likely to become increasingly modified to protect coastal assets from flooding and, increasingly, saline intrusion (Floerl et al., 2021; Hinkel et al., 2014). Considerable expansion in the extent of coastal hardening is projected over the next 25 years (Floerl et al., 2021) and this is likely to include the construction of new in-channel barriers (John et al., 2022; Kidd et al., 2015; Mohammed and Scholz, 2018; Morris, 2013), increasing the number of estuaries subject to estuarine squeeze.

3. Consequences of estuarine squeeze

The tidal freshwater zone is most vulnerable to estuarine squeeze, being at the top of the estuarine transition, though the oligohaline zone (salinities of >0.5–5) may also be at risk in some systems (Fig. 2). Due to tidal energy and fluvial water chemistry, TFZs are hotspots of biogeochemical cycling (O'Connor et al., 2022). They process, recycle and retain key nutrients (C, N, P and Si) delivered from the terrestrial catchment (Knights et al., 2017; Xu et al., 2021). The downstream boundary of the TFZ also abuts the oligohaline zone and complex biogeochemical reactions occur where the freshwater and saltwater meet (the freshwater-seawater interphase; Morris et al., 1978) and the turbidity maxima forms (Jay et al., 2015). The TFZ also plays an important role in estuarine food web functioning (Muylaert et al., 2005; Young et al., 2021). High allochthonous particulate and dissolved organic matter input from the catchment and autochthonous productivity mean large quantities of organic matter is available to decomposers, zooplankton, detritus-feeding invertebrates and other estuarine consumers (Little et al., 2022). Benthic invertebrates are themselves abundant prey and this zone is an important habitat for many economically, recreationally, and ecologically important fish and bird species (Covich et al., 1999; Kraus and Secor, 2005; Pihl et al., 2002). Half of all fish species that utilise estuaries may rely on the TFZ for spawning, nursery habitats, foraging or as pathways for diadromous (catadromous or anadromous) migrations (Kraus and Secor, 2005; Pihl et al., 2002). These include endangered species such as the eel (*Anguilla anguilla*), salmon (*Salmo salar*) and river lamprey (*Lampetra fluviatilis*) (Le Pichon et al., 2017; Masters et al., 2006; Van Lieeringe et al., 2012; Wilson et al., 2016). The movement of organisms, organic matter, nutrients and other biogeochemical by-products downstream affects the water quality and chemistry of the brackish estuary and provides trophic subsidies to the estuary (O'Connor et al., 2022; Williams and Williams, 1998) and the riparian zone (i.e. through aquatic insect emergence; Dias et al., 2016). Exported organic matter and organisms are consumed and incorporated into the food web in these adjacent zones (Dias et al., 2016; Kautza and Sullivan, 2016; Williams and Williams, 1998; Zapata and Sullivan, 2018).

Reduction and/or loss of the TFZ through estuarine squeeze will result in the reduction and/or loss of the processes and functions it provides, which may detrimentally impact the brackish estuary and coastal zone, but also the adjacent non-tidal river and riparian zones (Ensign and Noe, 2018). Changing water chemistry and other environmental conditions through the extension of the saline front will force changes in biogeochemical reactions (e.g. increasing N & P exchange and N_2O production; O'Connor et al., 2022) and nutrient cycling (e.g. through changes to allochthonous organic matter breakdown; Franzitta et al., 2015) impacting water quality and food web functioning downstream. The longitudinal salinity gradient is the primary driver of community composition in estuaries (Whitfield et al., 2012). Increasing salinities will result in changing distributions of taxa (Douglass et al., 2020; Lauchlan and Nagelkerken, 2020; Little et al., 2017b) and intertidal habitats based, in part, on salinity tolerance (Kirwan and Gedan, 2019; Li et al., 2022; Magolan and Halls, 2020; Parker and Boyer, 2019; Saintilan et al., 2020). Sensitive freshwater species will be lost or shift upstream and will be replaced by brackish and marine-derived species, altering estuarine food webs through changing trophodynamics (Attrill et al., 1996; Bessa et al., 2010; Kasai et al., 2010; Martinho et al., 2007; Muylaert and Sabbe, 1999). Where the TFZ is completely squeezed out, the loss of freshwater flora, fauna and habitat below the in-stream barrier will create a sharp division between upstream non-tidal freshwater and downstream brackish or marine habitats (depending on the degree of squeeze). Loss of TFZ habitat will particularly impact fisheries, through the loss of suitable reproductive and foraging habitat and nursery grounds for estuarine, riverine and diadromous species (Pihl et al., 2002).

The significance of the impact of estuarine squeeze will depend on the rate of squeeze and the spatial extent of the TFZ. Rate will depend on the bathymetry of the estuary (depth, cross-sectional area and bed gradient), catchment and channel modification, RSLR and reductions in river flow. Changes in river flow may be key in determining the rate of squeeze, as in some systems this has a greater impact in determining saline intrusion extent than sea level (Little et al., 2017b). The impacts of estuarine squeeze may, therefore, be seen more rapidly than would be expected for RSLR alone, as globally many river basins already suffer from unsustainable extraction regimes and experience some degree of water stress (i.e. the proportion of water withdrawal with respect to total renewable resources) affecting river flow in downstream areas (Rodda, 2006; Veldkamp et al., 2017; Wada and Bierkens, 2014). Severe water stress in river basins is forecasted to increase under future population growth and climate scenarios (Lehner et al., 2011; Schröter et al., 2005) and it is estimated that by 2050 more than half the world's population will live in water-stressed areas (Schewe et al., 2014; Schlosser et al., 2014).

4. Conclusion

Globally, many estuaries are already suffering from the effects of saline intrusion driven by rising sea levels and/or reductions in river flow. Whilst there has been a recent proliferation of studies investigating the impact of this on estuarine intertidal habitats through coastal squeeze (particularly tidal freshwater marshes), no studies (to our knowledge) have assessed the loss of subtidal zones in the upper estuary against in-channel man-made barriers. Here we have defined the concept 'estuarine squeeze' and highlighted that the TFZ, at the top of the estuarine transition, is most at risk of loss or reduction in extent via this increasing problem.

Our knowledge of the functioning of the TFZ remains limited, but it is becoming increasingly clear that the TFZ is a critical facilitator of biological, chemical and physical connectivity and processing in estuaries, linking the terrestrial catchment and river to the brackish estuary and coastal zone (Little et al., 2022; O'Connor et al., 2022). It is likely that the TFZ significantly contributes to the key estuarine ecosystem processes and functions of organic matter processing and nutrient cycling (regulating water quality downstream) primary and secondary production and the provision of habitat for resident and transient species and communities (supporting biodiversity and maintaining fisheries) (Millenium Ecosystem Assessment, 2005). Loss of the TFZ through estuarine squeeze may, therefore, result in a net loss of function (Ensign and Noe, 2018), with critical implications for the ability of estuaries to continue to provide these ecosystem services into the future.

The future loss of these zones may require mitigation through a new tidal freshwater conservation agenda, focussed on restoration through appropriate channel management, and reconnecting and creating (e.g. through managed realignment) tidal freshwater floodplains (e.g. Beauchard et al., 2013; Temmerman et al., 2013). Such an approach would align with the drive for nature-based solutions for the post-2020 nature, climate and sustainable developments agendas (Cohen-Shacham et al., 2016; Hobbie and Grimm, 2020). The risk presented to the TFZ through estuarine squeeze needs to be a key priority of future estuarine research. This should focus on detailed studies of the structure and functioning of this zone (Ensign and Noe, 2018), improving metrics for assessment (e.g. Wilson et al., 2017) and appropriate management strategies and tools which would identify zones at risk of degradation and loss (e.g. Pickwell et al., 2022) and focus conservation attention and if necessary, intervention.

CRediT authorship contribution statement

Sally Little: Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Jonathan P. Lewis:** Writing – review & editing, Writing – original draft, Investigation. **Helen Pietkiewicz:** Writing – review & editing, Writing – original draft, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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