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EDITED BY
Kum Fai Yuen,
Nanyang Technological University, Singapore

REVIEWED BY
Han Zhang,
Ministry of Natural Resources, China
Shih-Ming Kao,
National Sun Yat-sen University, Taiwan

*CORRESPONDENCE
Wenxian Qiu
qiuwenxianlaw@163.com

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Assessing the impact of sea level rise on maritime entitlement and delimitation: an interdisciplinary investigation through legal and technical analysis

Tsung-Han Tai[1] and Wenxian Qiu[2]*

[1]School of Law, Shandong University, Qingdao, China, [2]Guanghua Law School, Zhejiang University, Hangzhou, China

This paper delves into the complexities of maritime delimitation in the context of sea level rise (SLR) and ice-covered regions, examining several factors and legal implications. Through academic discussion and technical analysis, the adjustments is required in approaches to the Exclusive Economic Zone and the continental shelf boundaries' delimitation amidst SLR, while the different models adopted by adjacent and opposite states are presenting. As a result, the paper provides a comprehensive overview of common issues surrounding baseline determination, particularly in relation to SLR and the challenges posed by off-shore features. Legal dynamics concerning 'submarine ridges' versus 'oceanic ridges' are explored, highlighting the complexities inherent in maritime boundary delineation. Additionally, the dynamics of basepoint selection in ice-covered regions is investigated, emphasizing essential criteria for navigation and offering case studies from the Antarctic and Arctic here. Through this exploration, the paper contributes to a deeper understanding of the challenges and considerations involved in maritime delimitation amidst SLR, offering valuable insights from both technical and legal perspectives.

KEYWORDS

United Nations Convention on the Law of the Sea (LOSC), sea level rise, foot of the slope, low tide elevation, maritime delimitation

1 Introduction

1.1 Background

With the birth of the 1982 United Nations Convention on the Law of the Sea (hereinafter, the Convention), maritime delimitation has become more complex and difficult for coastal states. There are more than one delimitation approaches that the costal state can choose to negotiate with its neighbors. According to Articles 74 and 83 of the Convention, the delimitation of the Exclusive Economic Zone (EEZ) and the

Continental Shelf (CS) between states with opposite or adjacent coasts shall be affected by agreement on the basis of international law, as referred to in Article 38 of the Statute of the International Court of Justice, to achieve an equitable solution. That is to say, as long as the delimitation result can meet the criterion of justice and equity, which can reflect the common will of the parties, the result is supported and recognized by the Convention.

In practice, reality often deviates from theory. When it comes to defining the boundaries of the CS, states face significant controversy due to the lack of clear guidelines in the Convention on how to choose the right approach for delimitation. Primarily, states with geographical advantages assert their claims to a CS based on the natural prolongation criterion, whereas those with geographical disadvantages resort to the 200 nautical miles (NM) distance criterion for delineating CS boundaries. Additionally, Article 76 (10) of the Convention provides a general legal principle stipulating that "delineating the outer limits of the CS are without prejudice to the question of delimitation of the CS between States with opposite or adjacent coasts." However, the phrase "without prejudice" in this context introduces ambiguity, leading to legal uncertainty in its interpretation. In cases in which legal clarity is lacking, states with geographic advantages tend to claim CS areas beyond 200 NM using the natural prolongation criterion (e.g., China in the East China Sea and Bangladesh in the Bay of Bengal), whereas those at a disadvantage opt for equidistance lines as the single maritime boundary within 200 NM to delineate overlapping zones, rather than seeking the outer limits of the CS (e.g., Japan in the East China Sea and Myanmar in the Bay of Bengal).

Today, the occurrence of the "submerging island" is happening. Climate-change-induced sea level rise (SLR) in small island developing states (SIDS) continues to be the most pressing threat not only to their freshwater resources, biodiversity, and socio-economic progress, but also their sovereignty, maritime entitlement, and human rights. This raises significant concerns about the application of maritime rules, particularly regarding the appropriate delimitation methods in the context of SLR (United Nations, 2015; Stocker et al., 2013).[1] The Intergovernmental Panel on Climate Change (IPCC) released its Special Report on the Ocean and Cryosphere in a Changing Climate on 25 September 2019. Over 100 scientists from 36 countries drew from approximately 7,000 scientific publications to assess the latest research on climate change's effects on the ocean and cryosphere. Key areas of focus include glacial melting, coastal erosion, and impacts on high-mountain regions (670 million residents), low-lying coastal areas (680 million residents), polar regions (nearly 4 million residents), and SIDS (approximately 650 thousand residents). Projections indicate that approximately 70% of global coastlines will experience sea-level changes, either retreating landward or shifting seaward (IPCC, 2013).[2] According to the latest IPCC report, the global surface temperature was 1.09°C higher in 2011–2020 than in 1850–1900, with a rise in the global surface temperature since 1970 that has accelerated faster than in any other 50-year period over at least the last 2,000 years (IPCC, 2023).

1.2 Methodology

Climate change-induced SLR has led to shifts in coastal states' baselines and changes in basepoints, posing significant challenges. These challenges encompass not only the selection of new basepoints for operational purposes but also involve legal applications and interpretations of UNCLOS and international law in determining potential new basepoints (International Law Association, 2012).[3]

When concerning the issue of determining the baseline for a coastal state, there are different views in the international community. The straight baseline claims of 91 States that have been identified are protested by no less than 25 State Parties (International Law Association, 2014). When people are still discussing whether the distance between the basepoints should be limited (International Law Association, 2015), the change in global sea level exacerbates the uncertainty of the rule application (Caron, 1990). As the work of the International Court of Justice (ICJ, 2007),[4] International Law Association (ILA), and

1 In recent years, several outstanding events in the law-making process of climate change have occurred constantly. For instance, the 25th anniversary of the entering into force of the United Nations Framework Convention on the Climate Change (hereinafter: UNFCCC) took place in 2019. Implementation of the Paris Agreement has begun since 2020. At this stage, the UN Climate Change Conference was held in Madrid, Spain, from 2 December to 15 December 2019. Nearly 30,000 representatives from 196 countries and regions engaged into further negotiations on the implementing rules of the Paris Agreement. In fact, the international multilateral fora have focused on climate change since 1970 with a series of high-level seminars, for example, the Toronto Conference in June 1988, the Ministerial Conference on Air Pollution and Climate Change in Dervik, Netherlands, in November 1989, and the Ministerial Conference of the Second World Climate Conference in Geneva in November 1990. These conferences argued that immediate measures should be taken to deal with climate change and calling for the preparation and adoption of a convention comprehensively with regard to climate change.

2 For example, coastlines closing current and former glaciers and ice sheets are experiencing relative sea-level fall. According to Nicholls, relative sea level is falling due to ongoing glacial isostatic adjustment-induced rebound in some high-latitude locations that were sites of large glaciers, such as the northern Baltic and Hudson Bay.

3 In the 2012 Sofia Conference report, the question of how to assess whether there was a need to further clarify the existing law was put forward. It is necessary to make sure how to provide a legal explanation reasonably given the impact of sea level change. The Committee concluded that the normal baseline is considered as an ambulatory limit, moving seaward or landward caused by the natural changes or human behaviors.

4 The International Court of Justice (ICJ) is currently examining whether the existing basepoints accurately represent the true coastal configuration. According to the ICJ's 2007 judgment in the case of Nicaragua vs. Honduras, a point is deemed unsuitable as a basepoint if it fails to correspond to the actual low-water line following a rise in sea levels.

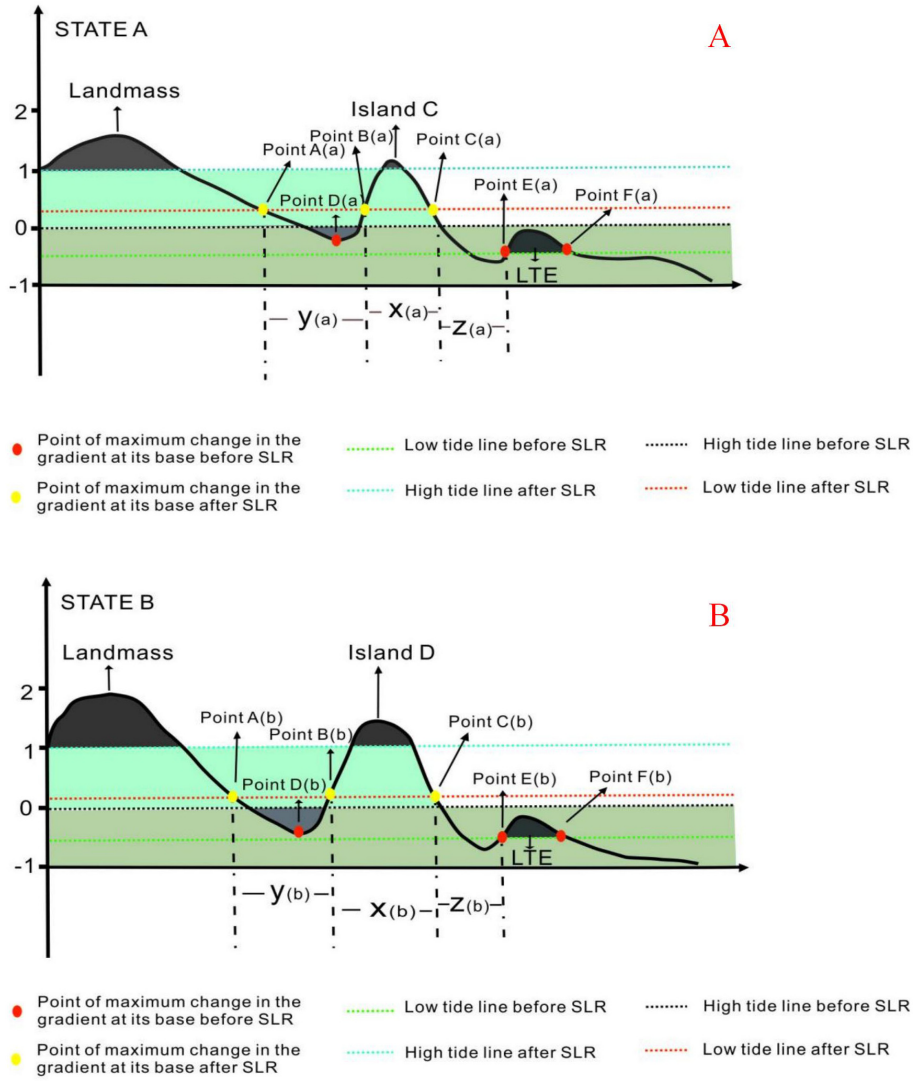

FIGURE 1
(A, B) present different changes in legal attributes in similar geomorphological contexts, as illustrated by the authors.

International Law Commission shows, there appears to be a significant appetite for clarity in how climate change impacts upon the law of the sea, and *vice versa* (Barnes, 2022). [5]

Thus, this research aims to explore the impact of SLR on maritime entitlement and delimitation, employing an interdisciplinary approach that combines technical and legal perspectives. To achieve this aim, the article delves into three primary aspects. First, it examines alterations in basepoints. Part 2 of the article elaborates how SLR affects the alteration of legal status concerning coastal states' 'offshore high tide features' and 'submarine heights' [6](as depicted in Figures 1, 2). Second, in part 3, it considers the hypothesis that coastlines may shift either seaward or landward due to SLR. Through several models (as illustrated in Figures 3–5), this paper examines how SLR impacts the delimitation of overlapping sea boundaries between EEZ and CS, involving adjacent and opposite states. Finally, the article addresses the challenge posed by potential changes in baselines due to ice melting in polar regions. In part 4, the authors advocate for increased attention to these issues and propose

5 As the International Law Association (ILA) Committee asserted at the Sydney Conference, it focuses on the legal consequences of sea level floating and seeks to minimize proposed changes to the law of the sea, especially how to reduce the legal uncertainties regarding the global maritime area division to keep the relations orderly and peaceful between states. In accordance with the purpose of the Convention, any fundamental change in the existing legal principles and in corresponding state practice should be dealt with in a process aimed at keeping the legal system stable and impartial. Three words, 'peace', 'progress' and 'justice', are from the first paragraph of the preamble to the Convention.

6 In Figure 1, 'offshore high tide features' include the island and the low-tide elevation (LTE), which are both marine geographical concepts. In Figure 2, 'submarine heights' include the kinds of ridge-bodies, such as the submarine elevation, submarine ridge, and oceanic ridge, all of which are the legal concepts from the LOSC.

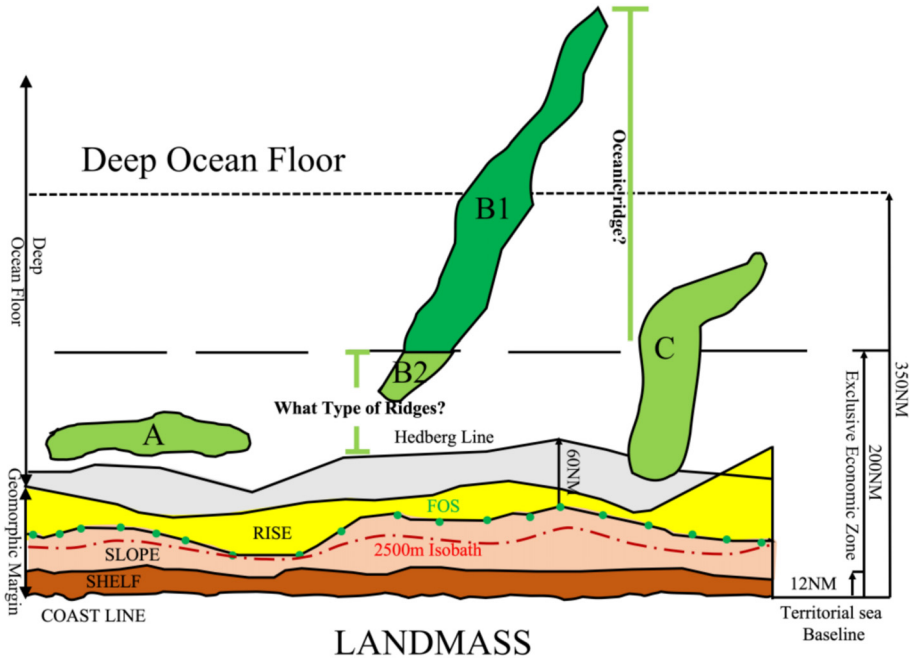

FIGURE 2
Diagram of ridge interpretation with the geomorphic margin. Modified from Taft and Kagami (2000).

navigating basepoint factors amidst ice melt, using case studies from the Antarctic and Arctic regions.

2 Common issues concerning the fundamental delimitation's factors along with the SLR

Owing to the SLR, the assumption of stable geography no longer exists, even without considering the movement of the earth's crust. The recognition that substantial loss in territory resulting from the SLR is an issue that extends not only to the implications for the law of the sea, but also encompasses greater consideration on the norms' explanation (International Law Association, 2018). The challenge is the scientific information overload and concerns about whether this could be synthesized effectively within the confines of legal advisory (Barnes, 2022).

2.1 Fixing the basepoints along with the off-shore features' floating

Baselines play three roles in determining the maritime zones: (1) dividing the internal waters from the territorial sea (TS), (2) calculating the distance from the outer limits of different maritime zones, and (3) fixing the boundaries of the overlapping areas between two coastal states. These roles may also be separated or grouped on the basis of their unilateral or bilateral aspects (International Law Association, 2012). According to Article 121 of the Convention, a "full-fledge island" can generate its own TS, contiguous zone, EEZ, and CS (Roach, 2015).[7] However, an island that cannot satisfy the conditions in paragraph 3 of Article 121, in which it cannot sustain human habitation or economic life of its own, is considered as a 'rock', which cannot generate an EEZ or a CS. With the natural changes caused by the SLR, it seems difficult to maintain all conditions to be a "full-fledge island", especially the two conditions 'above water at high tide' and 'sustain human habitation or economic life of their own'. In other words, an increasing number of islands will naturally transform into rocks in the legal sense without human intervention (Soons, 1974; Bowett, 1978; Oude Elferink, 2012; Stoutenburg, 2019).

The traditional approach to baselines is not well suited to the current situation in which significant territorial losses are caused by SLR (Barnes, 2022). As Storlazzi et al. (2018) said, most atolls will be uninhabitable by the mid-21st century because of SLR exacerbating wave-driven flooding (Storlazzi et al., 2018). In the tropics, where the sea levels are rising at the highest rates, thousands of low-lying coral atolls are located. In addition, the annual flooding also makes islands uninhabitable because of frequent damage to infrastructure and the inadequacy of their freshwater aquifers (Marty Koller et al., 2021). When mean sea level is 1.0 m higher, at least 50% of the islands are projected to be flooded. There are also some islands that will directly become LTEs provided by Article 13 of the Convention or even submarine highs provided by Article 76 (including submarine elevations, submarine ridges, and oceanic ridges). According to Article 13, when a feature is an LTE and thus can

7 The land feature that is able to sustain human habitation or has an economic life of its own and can generate an EEZ or a continental shelf has been called a "full-fledged island".

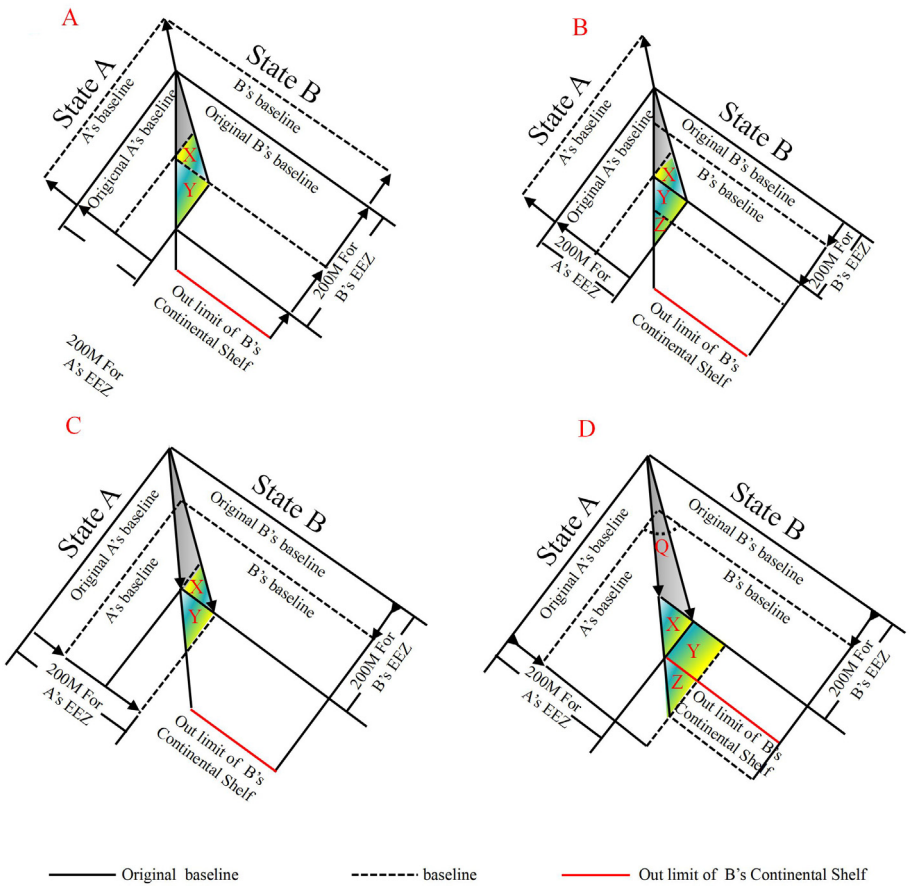

FIGURE 3
(A–D) present sketches of adjacent states after sea level changes, as illustrated by the authors. The arrows indicate the direction of sea level movement, either seaward or landward.

be used as a basepoint depends on its height relative to the vertical datum and its horizontal location relative to the nearest mainland or island (International Law Association, 2015). Therefore, geographical features lying under water at high tide are highly susceptible to sea level change, especially if they have been used for determining the basepoints (International Law Association, 2018).

The LTE was regarded as an island until the 1958 Convention on the Territorial Sea. Then, the situation of low-lying coastal area was discussed successively in the ILA report at the Sydney Conference in 2018 and the IPCC report on the ocean and cryosphere in 2019 (Caron, 1990; Mendenhall, 2019). Although the coastal States could undertake physical measures to keep their baselines stable, it seems not an appropriate option in the face of rising global sea levels. Some scholars have proposed the practical approaches to clarifying relevant rules in the Convention, for example by freezing the status of islands, baselines, or outer limits of maritime zones (Schofield, 2010, 2012). However, at the Singapore Intersessional Meeting in 2018, it was suggested that the use of the word 'freezing' was misleading. The terminology 'maintaining existing entitlement to maritime zones' is acceptable only on the basis that the fixed outer limits of the maritime zones have already been delineated (International Law Association, 2018). The Commission of small island states on climate change and international law was established on 31 October 2021 (The Secretary-general of the United Nations, 2021). In such circumstances, it is necessary to make a legal interpretation and supply a physical justification that the entitlement derived from the previous offshore sea features that has disappeared should be preserved.

T o highlight the legal attributes transforming maritime zones, including the landmass with the LTE, Figure 1 makes a comparison with two models and reflects the change in the claimed maritime zones in detail. Both State A and State B have a landmass and an offshore island with an LTE outward, respectively. Additionally, the slope of State A's continental margin increases gently, whereas the slope of State B's continental margin increases steeply. When the sea level rises in one unit represented by the number in the Y-axis, the distance by which the coastline of State B recedes is obviously less than the one in State A.

Most importantly, the role of the LTE in claiming for the outer limits of the maritime zones is different before and after the SLR. According to Article 13 of the Convention, an LTE is a naturally formed area of land, which is surrounded by and above water at low tide but submerged at high tide. On the one hand, when an LTE is situated within the breadth of the TS from the mainland or an island, its low-water line can be considered as the baseline and used to extend maritime zones. Only when the LTE is wholly situated beyond 12 NM from the landmass, it has no claimed zones of its own.

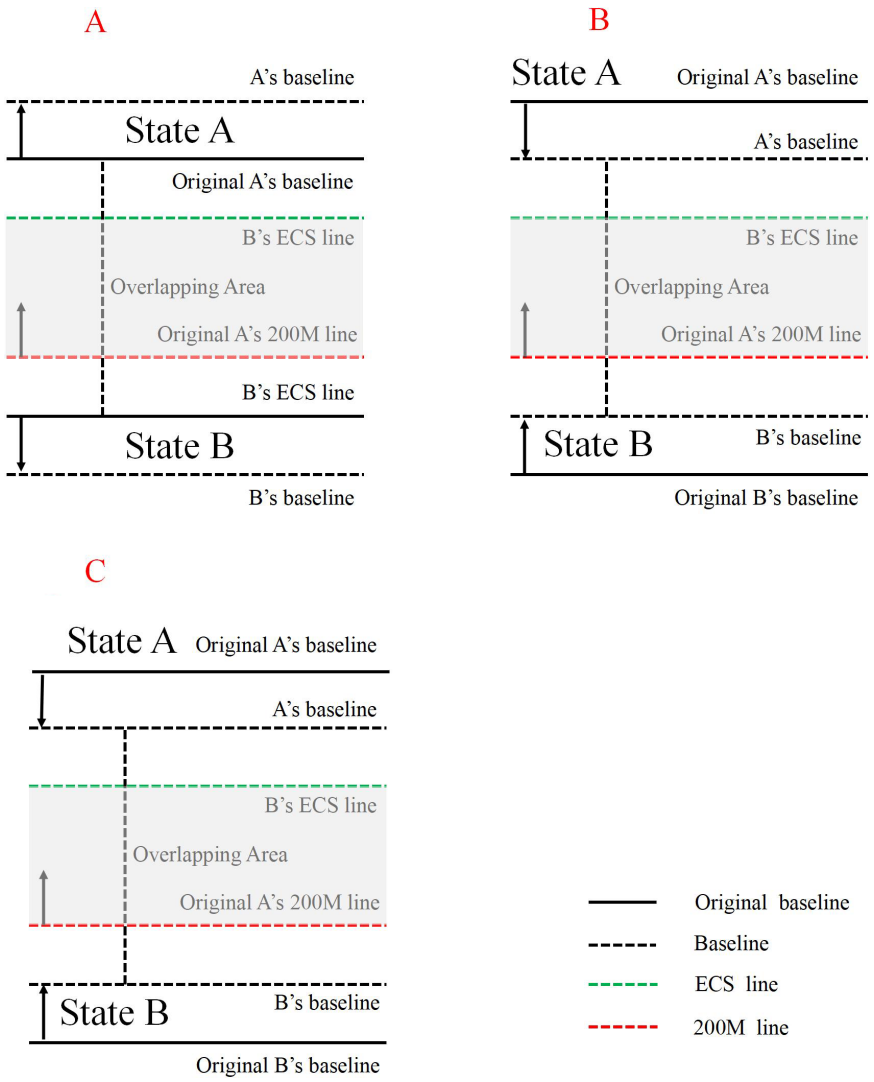

FIGURE 4
(A–C) present changes in opposite states over a distance of more than 400 NM, as illustrated by the authors.

2.1.1 Determining the baseline before SLR[8]

(a) Concerning State A: the continental slope from the landmass is gentle and Island C is situated more than 12 NM from the landmass, which meets the distance between landmass and the island up to 12 NM but less than 24 NM in Figure 1A, whereas the LTE is situated within 12 NM from Island C. At the moment, the furthest point of maximum change in the gradient around the landmass of State A can be identified as Point D(a) in Figure 1A. The outermost point of maximum change in the gradient around Island C is point F(a). According to the principle 'the land dominates the sea', State A can claim maritime zones from the landmass and the island.

(b) Concerning State B: the continental slope from the landmass is steep and the LTE is situated within 12 NM from the landmass, which also places it within the z(b) distance of 12 NM from Island D in Figure 1B. According to the location of the landmass and the nearshore Island D, there is no doubt that the LTE is also situated within 12 NM from Island D. Therefore, the LTE can be used as the starting line for measuring the breadth of the TS even from Island D. Point F(b) can be used as the furthest point of maximum change in the gradient for the landmass and Island D before SLR. In this situation, the landmass and Island D can be considered as a whole to project the TS, EEZ, and CS from the baseline around the LTE. The water area between the landmass and the island constitutes the whole internal waters and part of the TS of State B at the moment.

When the sea levels begin to rise, the LTE will be submerged at the low tide line. Point F(a) and Point F(b) cannot be considered as the potential basepoints for maritime projecting prolongation. Then, what will take place concerning the baseline for two States?

8 It should be noted that according to Article 7(4) of the Convention, the low-tide elevation can be considered as the potential basepoint only if there are lighthouses or similar installations that are permanently above sea level on the LTE.

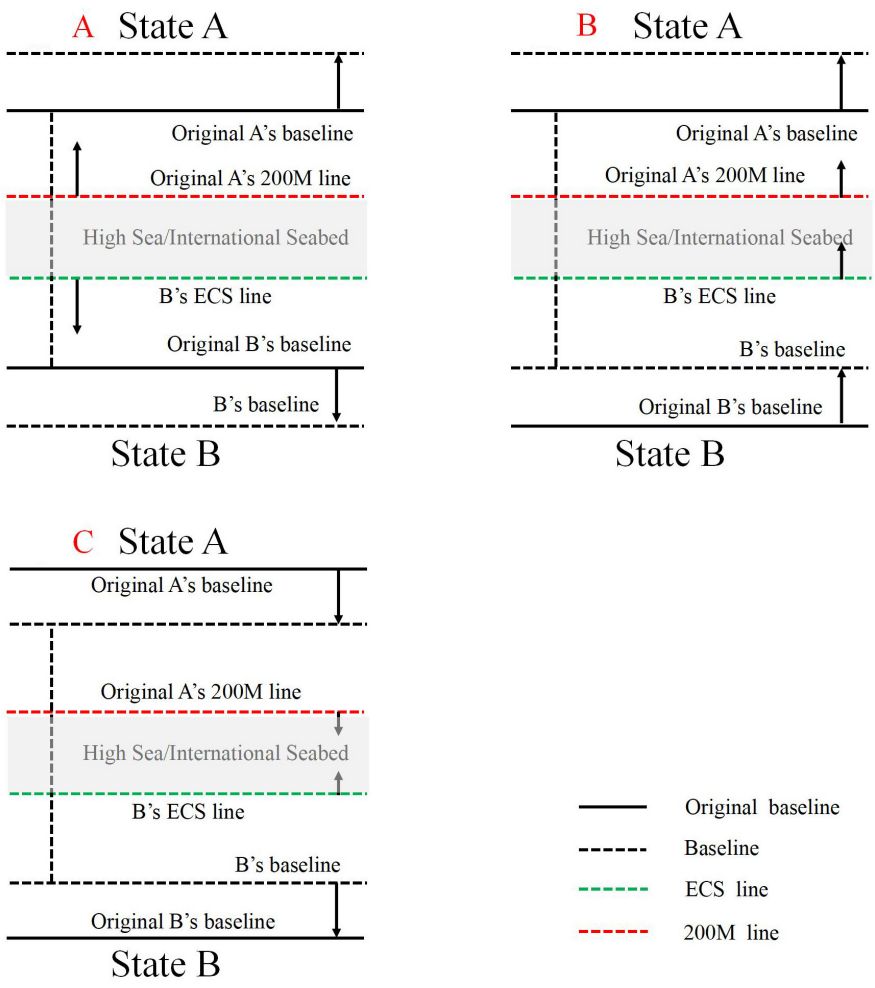

FIGURE 5
(A–C) present changes in opposite coastal states within a distance of 400 NM, as illustrated by the authors.

2.1.2 Determining the baseline after SLR

Concerning State A: when the sea level rises in one unit, the LTE will be completely submerged and will no longer be above water, even at low tide. Concerning the landmass, the furthest potential basepoint retreats landward from point D(a) to point A(a). Concerning Island C, owing to the disappearance of the LTE, point B(a) and point C(a) can be fixed as the basepoints and a claim for maritime zones from the island can be made in the envelope of arcs circular (Kastrisio and Tsoulos, 2016). The legal nature of the water areas between the landmass and Island C depends on the distance from the claimed maritime zone from the landmass.

Concerning State B: when the sea level rises in one unit, the LTE will be completely submerged, even at low tide. Owing to the disappearance of Point F(b), the condition of State B to fix the potential basepoints will depend upon the distance between the landmass and Island D after the SLR. If the coastal circumstance after the SLR is that y(b) is less than 12 NM, Island D is still a nearshore island within 12 NM from the landmass. Therefore, the landmass and Island D can be considered as a whole and the potential furthest basepoint is point C(b) after the SLR. Or, if y(b) is up to 12 NM after the SLR, Island D is no longer within 12 NM from the landmass. The landmass and Island D cannot be considered as a whole to claim for maritime entitlement. Concerning the landmass, the potential basepoint can be fixed on point A(b) by tracking the intersection between the low tide line and the continental slope. Concerning Island D, point B(b) and point C(b) can be fixed as the basepoints and then used to claim for maritime zones in the form of envelope of arcs. Owing to the steep slope, Island D will easily turn into a low-lying island, provided the sea level rises to a certain extent. At the time that the distance between Island D and landmass is up to 12 NM, the legal attributes of water area between point A(b) and point B(b) will transform into a variety of maritime zones, rather than only internal waters or TS.

In short, the LTE is submerged totally, and after SLR, the original furthest Point F(a) disappears for State A as well as Point F(b) for State B. The area of maritime zones for which State A can claim is likely to change obviously, especially the legal attributes of the water area between the landmass and the island. By contrast, concerning the claimed area of maritime zones, State B with the steep slope is affected by the SLR much less than State A with the

gentle slope.[9] The decreased projecting areas of State A and State B depend on the distance that the baselines retreat.

2.2 New difficulty derived from the jumping around the submarine highs of the FOS

2.2.1 Legal implications of submarine ridges versus oceanic ridges

The concept of the foot of the slope (FOS) is set out in paragraph 4(b) of Article 76 in the Convention. Meanwhile, Article 76 provides no specific maximum extent to the continental margin. Its outer edge is established by measurements based on the FOS envelop (Brekke and Symonds, 2011). The CS, however, is subject to maximum constraints as provided for in paragraph 5 of Article 76. The basis here is the geographical location from the continental slope to the continental rises within the whole continental margin. The area of the continental margin comprises the submerged prolongation of the landmass and consists of the seabed and subsoil of the shelf, the slope, and the rise, including the submarine elevations. As per Article 76(5) of the Convention, the outer limit of the CS can extend up to 350 NM from the baseline around what are referred to as "submarine ridges". However, what is commonly referred to as an "oceanic ridge" encompasses features like "submarine elevations," such as plateaus, rises, caps, banks, and spurs as stipulated in Article 76(6), and "oceanic plateau" in Article 47(7), none of which contribute to the natural prolongation for the FOS.

2.2.2 Legal dynamics of submarine and oceanic ridges

According to Symonds (2000), both ridge A and part of ridge B (that is B2) lie beyond the edge of the continental rise but within 200 NM from the baseline. Part of ridge B (that is B1) lies beyond 200 NM in Figure 2 (Taft and Kagami, 2000). The only difference is that, based on the relationship between the submarine highs and the sea level floating, the location of ridge A is much closer to the geomorphic continental margin than the whole of ridge B along the landmass. Therefore, ridges A and B2 within the 200 NM line can be considered as submarine ridges to fix the FOS and claim for the extended CS within the 350 NM from the baseline to the maximum extent. Ridge B1 beyond 200 NM tends to be the oceanic feature as it is cut off by B2 from the physical continental margin (Brekke and Symonds, 2011). No matter how much the sea level changes and how long the coastline moves, the legal nature of ridge A as a submarine ridge remains stable, because the construction of the physical continental margin remains stable.

If the sea level decreases, the baseline will shift toward the sea. Consequently, a portion of ridge B1 will transform into a submarine ridge, aligning with the movement of the 350 NM line seaward. In essence, the decline in sea level could expand the outer limits of the CS as ridge B1 gradually transitions from an oceanic ridge to a submarine ridge. On the contrary, if the sea level rises, the baseline will move landward. Part of ridge B2 becomes an oceanic ridge with its standing beyond the floated 200 NM line from the baseline. That is to say, the SLR will lead to the outer limits of the CS moving landward accompanied by the legal attribute change of ridge B2.

The situation of Ridge C is more complex than the previous two ridges. Ridge C develops from the continental margin, then jumps over then 200 NM line and arrives at the deep ocean floor. It is partly standing on the continental margin, partly lying from the continental margin to the 200 NM line as a submarine ridge, and partly prolonging beyond the 200 NM line as an oceanic ridge. However, the change in sea level on Ridge C will lead to three legal roles concerning different parts of Ridge C transforming each other. Owing to a large proportion of Ridge C standing within 200 NM, the impact of sea level change on Ridge C is much less than that of Ridges A and B.

3 Maritime delimitation challenges amidst SLR: adjusting approaches between EEZ and CS boundaries

Although the International Law Commission is examining sea-level- related aspects of climate change under its program of work, this is not a project concerning the development of new rules, but rather a mapping exercise designed to assist States in responding to the challenges of SLR (United Nations, 2018).

3.1 Four types of models from adjacent states

Coastal geography is considered as the significant context in delimiting boundaries between coastal states. Given a maritime area where neighboring States have delimited with a boundary, in case either State create new jurisdictional zones due to SLR, does the existing boundary can be direct prolongating for dividing potential new overlapping areas? As there is still no corresponding norm in the international treaties at all, how to fix the certain useful elements is still a question. The principal issue here in new zones is how to keep the balance between the need for any permanent boundaries and the necessity to make the related countries reach an agreement under this new circumstance (Papanicolopulu, 2006).

The SLR is not globally uniform and varies regionally. Regional differences, within ±30% of the global mean SLR, result from variations in ice-loss on land and variations in ocean warming (IPCC, 2019). This natural phenomenon makes delimiting maritime boundaries between adjacent or opposite states more difficult than delineating the outer limits for one coastal State (Gerald, 2018). First of all, there are two directions that the coastline might move: seaward or landward. Concerning adjacent State A and State B with an overlapping area, there are four types classified by the direction of movement of the coastal State's coastline in Figure 3. State A with a narrow continental margin has an EEZ and a CS extending to 200 NM. State B with a wide continental margin can claim for an extending area of the CS beyond

9 The steeper the angle at which the land slopes into the sea, the smaller the area of land that will be covered by SLR. Conversely, the gentler the slope, the larger the area that will be covered.

200 NM. The original outer limit of the CS for State B is drawn by the red line.

In Figure 3A, both coastlines of State A and State B retreat landward due to SLR. Therefore, the EEZ limits of State A and State B both retreat according to the 200- NM distance principle correspondingly. It is unique that the outer limit of State B's CS could tend to keep stable due to the certainty of the FOS in a geomorphic sense. Therefore, the area of the outer CS State B can claim for is increasing, provided that the final outer limit of the CS meets the condition that it is within 350 NM from the baseline or the 2,500 m isobath plus 100 NM. However, the original overlapping area of the waters above the seabed and subsoil between States A and B, which including the gray zone as well as areas X and Y, will now only comprise the gray zone, with areas X and Y being excluded. That is, the disputed area between States A and B will decrease along with the SLR.

In Figure 3B, the coastline of State A retreats landward due to SLR, whereas the coastline of State B moves seaward along with the sea level decline derived from certain coastal geographical features (Qiu and Firestone, 2020).[10] In a vertical perspective, the original overlapping waters superjacent are the gray zone with area X, whereas the original overlapping seabed and subsoil are the gray zone with areas X, Y, and Z. When the States' coastline floating occurs, both State A's and State B's EEZ and CF remain 200 NM wide. As State A's coastline retreats landward, its EEZ area decreases compared with its original EEZ area before the SLR. Conversely, as State B's coastline moves seaward, its claimed EEZ area increases. Consequently, the overlapping EEZ and CS areas within 200 NM between the two states shrink to only the gray area. There is no overlapping area between State A's EEZ and State B's outer CS (area z) anymore vertically. No delimitation dispute will exist between the EEZ regime and the CS areas for two States once two baselines move far enough, respectively.

In Figure 3C, the coastline of State A moves seaward due to the effect of certain coastal geographical features, whereas the coastline of State B retreats landward due to the SLR. Originally, the overlapping area of both the waters superjacent and the seabed with subsoil for two states is the gray zone. After the coastline floating, the EEZ and CS limits of State A move seaward, whereas the EEZ limit of State B retreats landward along with the baseline. The only limit that might remain stable is the outer limit of the CS of State B, as discussed in paragraph (b) and shown in Figure 3B mentioned above.

In Figure 3D, the coastlines of State A and State B move seaward and correspondingly the maritime zones claimed by the States move seaward as well. The projection under angle Q in the overlapping area becomes larger along with the distance from the landmass further. The overlapping area of the waters superjacent between two States increases from the gray zone to include areas X, Y, and Z. The overlapping area of the seabed with subsoil for two States expands from the gray zone with area X into the gray zone with areas X, Y, and Z.

3.2 Three types of models from opposite states up to 400 NM

Regarding the opposite States, Figures 4, 5 categorize them into two types based on the original distance between the States. Additionally, these figures classify three types according to the direction of the coastal state's coastline movement. In Figure 4, each original distance between State A and State B is up to 400 NM. State A in the geographical disadvantage has a 200 NM area of EEZ and CS, whereas State B in the geographical advantage can claim for an ECS beyond 200 NM. The green line represents the original outer limit of the CS for State B, and the red line represents a 200 NM line from State A's coastline.

In Figure 4A, the superjacent water stuck in the middle between two EEZs is the high sea, and the corresponding seabed and subsoil are either the outer CS of State B or the international seabed. After the SLR, both coastlines retreat and the superjacent water in the middle (namely the high seas) enlarges definitively. Even the outer limit of the CS for State B remains stable. The area of the international seabed will enlarge as well.

In Figure 4B, the superjacent water between the EEZ areas is the high sea, and the corresponding seabed and subsoil are either the outer CS of State B or the international seabed. Under the situation that the coastline of State A retreats landward and the coastline of State B moves seaward, the direction of the 200- NM lines of State A and State B will move along with the states' baselines, but the outer limit line of State B will be stable unless the foot of the slope needs to be re-identified. The changing areas of the high sea and the international seabed will depend on the floating distance between the baselines of State A and State B, as well as the outer limit of B's CS. These factors will dictate the shifting areas of jurisdiction.

In Figure 4C, the superjacent water between EEZ areas is the high sea, and the corresponding seabed and subsoil are either the outer CS of State B or the international seabed. Once the coastlines of State A and State B move seaward, the direction of the 200- NM lines for two states will move along with their baselines. In addition, the outer limit line of State B will be stable unless the foot of the slope needs to be re-identified. Thus, the reduced distance of the high sea' s width is equal to the sum of the distance that the two baselines move, whereas the reduced width of the international seabed is expected to be less than the altered width of the high sea.

3.3 Three types of models from opposite states within 400 NM

In Figure 5, each original distance between State A and State B are less than or equal to 400 NM. The geomorphological features of State A and State B are similar to the ones in Figure 4. The green line represents B's extended continental shelf (ECS) line, and the red line represents the original 200 NM line from State A's coastline.

10 From a geological perspective, it seems impossible that with two adjacent shorelines one retreats and the other moves seawards, such as in Figure 3B and Figure 3C. However, a similar situation is a reality; for example, in the situation regarding the coastline around the Gulf of Alaska, the directions of the sea level changes among Zone A, Zone B and Zone C are different.

In Figure 5A, the superjacent water in the gray zone is the overlapping of the EEZ, and the corresponding seabed and subsoil are the overlapping of two continental shelves. After the SLR, both coastlines retreat and the entitlement area for where each state claims might enlarge theoretically. The overlapping superjacent water with the CS decreases promptly. Owing to the determination of the FOS, the ECS line for State B remains stable and the overlapping area of the seabed with subsoil will decrease along with State A's 200 NM line falling back.

In Figure 5B, there is also an overlapping area of the EEZ and CS similar to Figure 5A. After the sea level declines, the overlapping area in the gray zone clearly enlarges. The legal attributes of the superjacent water as the overlapping EEZ and the seabed with the subsoil as the overlapping CS remain stable until the coasts of two States are quite close. Once the distance between two baselines becomes less than 24 NM, the overlapping area belongs to the overlapping of the TS and should be divided by the median line according to Article 15 of the Convention.

In Figure 5C, the gray zone represents an overlapping area of the EEZ and CS of two States. Under the situation that the coastline of State A retreats landward and the coastline of State B moves seaward, the direction of the 200- NM lines of State A and State B will move along with their baselines. State B's ECS line is stable unless the FOS needs to be re-identified. The changing areas of overlapping waters and the seabed with subsoil will depend on the D-value in the floating distance between two baselines for two States and the changing situation of the outer limit line of State B, respectively.[11]

4 Exploring basepoint dynamics in ice-covered regions: considerations and case studies—a pending discussion

4.1 Navigating basepoint selection in ice-covered areas: essential criteria

Article 234 of the Convention mentions ice-areas covered by glaciers or ice sheets for most of the year. These areas constitute approximately 10% of the earth's land area and support unique habitats. As ice-covered regions are mostly far away from human activity, there was no further discussion on the determination of the baseline and the boundary delimitation in them during the Third Session of the Conference on the Law of the Sea. Currently, there is a recognized method for determining the baselines that involves using stable ice-fronts or other unstable coast provisions according to Article 7 of the Convention, because ice more easily changes in volume and location, e.g., through periodical calving or gradual melting (Kaye, 2004).

In the eyes of geographers, ice mobility is likely the most common and significant hydrographic characteristic, regardless of its origin (Dutton et al., 2015). However, legal perspectives diverge when considering various types of ice, such as ice sheets, ice shelves, and ocean pack ice. In a legal context, the Convention does not address the distinct roles of these ice types nor how to establish the FOS in ice-covered regions. In the state practice, coastal States consider that the ice sheet and ice shelf have the same legal role as the landmass in fixing the baselines and delineating the outer limits only if the ice bodies remain constant through the years. In the case of R.V. Tootalik, Judge Morrow considered that the legal status of various types of sea ice in international law should be attached to the utilization in a manner closely analogous to land, which is attached stably to the shore at all times of the year, rather than pack ice floating free (Boyd, 1984).

The ice shelves covering or affixed to the land and originating within 12 NM from the coastline should belong to the coastal state as well. In such a situation, it can be applicable to choose the basepoint on the outer edge of the ice shelves for the purposes of Article 5 of the Convention. Also, Article 7 of the Convention is applicable for determining the straight baseline in the circumstance where the ice is too floating to make a TS projection as the basepoints. The outer edge of these ice bodies can be used for choosing the appropriate points as the basepoints for straight baselines only if the drawing line seems to be consistent with the general direction of the coastline and the projecting zone is closely linked to the landmass. Before delving into these provisions, it is crucial to assess the status of the ice along the coast to ascertain its relevance to baseline application. If a coastal State regards ice as permanent and equates it with land under Article 5, then Articles 7 and 10 may be of assistance in providing additional basepoints. Conversely, if ice is deemed incapable of generating TS basepoints, then Articles 7 and 10 may apply independently. Hence, the legal status of ice requires careful consideration (Kaye, 2004).

4.2 Navigating basepoint factors amidst ice melt: a case analysis of the Antarctic and Arctic

In a situation in which the ice bodies are equal in size to the landmass and begin to melt on a large scale, there will be a significant change not only on the general direction of the coast but also in fixing the basepoints. Some alternative points will tend to disappear along with the ice's melting. Furthermore, Hayton argued that the Antarctic Treaty (AT) had confirmed the assimilation between the ice shelves and the land in the area south of 60° latitude (Hayton, 1960). It seems that formations without sea water in between can be treated as land in Antarctica. In a word, the ice sheet and the ice shelf are the prolongation from and attached to the landmass, whereas the periodically floating ocean pack ice cannot be equated with land; it bears a closer resemblance to ships in its legal nature (Boyd, 1984). While the ice with a great age acknowledged as the land for determination of the basepoints, the frozen area naturally formed in a short period is not suitable for drawing baselines. Next, we take a look at the important ice-covered areas, the Antarctic and the Arctic.

11 The D-value indicates: The change in the overlapping area of the waters above is determined by the difference in the coastline shifts of the two countries. The overlapping area of the seabed is determined by whether the FOS of State B is affected by SLR. Generally, the probability of the FOS needing to be reselected due to minor sea level fluctuations is low.

There is a vast cap of ice covering most of the Antarctic continent, rising to over 4,000 m (Mangone, 2018). With developing maritime technology although the reappraisal forced by the widespread melting of the ice sheet seems feasible to distinguish between the land and the sea at a certain time, it would be impractical to distinguish from the ice shelf grafting on the sea floor and even floating ice at the surface, and would be difficult to identify precisely beyond a zone of a few kilometers (Boyd, 1984). It should be noted that the legal status of Antarctic waters is extraordinary as no recognized sovereignty has been established in the Antarctic continent. Sovereignty has been frozen by the AT. According to Article 4(2), no acts or activities for the coastal States shall constitute a basis for asserting, supporting, or denying a claim to territorial sovereignty or create any rights of sovereignty in Antarctica.

Although some States struggled to validify their claims over maritime zones in the Southern Ocean, no coastal State would be successful as long as the AT is in force and the relevant claims seem rather restrained or even invalid. For example, Australia (CLCS, 2004) and Norway (CLCS, 2009a) focused on the legal role of the ridges, plateaus, islands, and even the effect of different continental margins on fixing the FOS, rather than the ice-bodies in the Antarctic areas (CLCS, 2004, 2009b). Only in the CS preliminary information of Chile (CLCS, 2009c) was the pack-ice mentioned to have an effect on transporting the sediment from the land to the ocean and regarded analogous to the TS. T he Prague declaration of the 60th anniversary of the AT in 2019 emphasized the need to effectively promote the continued protection of the Antarctic environment. However, with the development of global climate change and the contemporary international norms, the pressure to expand the AT to satisfy members' appeals becomes greater. It is worth focusing on whether the claimant States may seek to amend the AT under the pretext of the melting ice sheet, aiming to expand their jurisdiction for land or marine environmental protection and preservation. Such efforts could potentially lead to boundary delimitation disputes in the future, as illustrated by Chile's submission to the Commission on the Limits of the Continental Shelf (CLCS).

As is known, the Arctic is an ocean composed of ocean pack ice surrounded by land. The main Arctic waters are in a long-term frozen condition and correspondingly the boundary between the outer edge of the ice sheet and the surrounding glacial lands remains indistinct. Based on the physical property of the water, the Arctic has a larger melting area than Antarctica. Through satellite observations, more economic opportunities for the exploration and exploitation of oil and gas have emerged with the melting of the ice. Stimulated by the potential great interests, the coastal States are predicted to pay more attention to the maritime claims. Based on the submissions received by the CLCS, most of the central Arctic areas have been claimed by Russia, Canada, Denmark, and Norway in a high degree of overlapping extended CS. There are only 149,000 km^2 left for the international seabed.

As an example, Norway claims a set of baselines around Spitsbergen, Nordaustlandet, Kvitoya, and Kong Karls Land in the Arctic, none of which are considered as ice features (Kaye, 2004). Charts of the Norwegian baselines around Svalbard show that the glaciers projecting into the sea have been intersected by the existed baselines. The most likely reason for keeping silent on the ice's role in the Norwegian case is that Gakkel Ridge constitutes most of the submerged prolongation of Norway's landmass (ICJ, 1951). In the Jan Mayen Case between Norway and Denmark in 1993, the role of ice has been considered as a special economic feature that seasonally restricts the access of migratory fishing to the waters, instead of a geomorphological feature that constitutes the baseline (ICJ, 1993). The basepoints claimed by Denmark and admitted by the International Court of Justice were constructed on the promontories and small islets (ICJ, 1993). The Jan Mayen area was also mentioned in the submission by Norway in 2006 (CLCS, 2006), but focused on geomorphologic prolongation between the Jan Mayen microcontinent and the Iceland plateau (ICJ, 1951).

Climate change is hitting hard, especially in vulnerable areas like the pole areas, making their impacts even more noticeable across the world. To prevent potential disputes in the future, it is worth noting that Arctic coastal States may consider the role of ice-coast as an alternative option for ECS if the CLCS rejects their previous submissions regarding the legal prolongation of specific submarine ridges. In addition, the overlapping claimed areas among Arctic States indicate to a high degree that the maritime boundary disputes will exist during a certain period and stand in the way of the CLCS in making the recommendation for the submissions according to Annex I 5(a) of the Rules of Procedure of the CLCS.[12] Furthermore, based on the complex geomorphological situation in the Arctic, it appears a great challenge for the international judges to make an equitable judgment on the delimitation disputes, or for the International Seabed Authority to confirm the area of the international seabed in the absence of the outer limits of the coastal States approved by the CLCS.

5 Conclusion

The International Tribunal for the Law of the Sea (ITLOS) should not be expected to be an arbiter of scientific issues (Bodansky, 2017). Therefore, it is important to clarify how to provide a developmental legal explanation on maritime delimitation under the impact of sea level changes that significantly impact the sovereignty, sovereign rights, and maritime jurisdiction of coastal states. The outer limits of maritime zones and even maritime boundaries with neighboring states should be projecting upon the existence of the baselines. The existing delimitation clauses of the Convention are adopted based on a plausible assumption that the maritime geography remains stable compared with human society and the legal system. Given the changing sea levels, we have to admit that an adjustment in the relevant norms in the Convention is required.

Therefore, the impact of SLR has sparked intense debate within the international legal community regarding the suitability of

12 Annex I 5(a) of the Rules of Procedure of the CLCS states 'in cases where a land or maritime dispute exists, the Commission shall not consider and qualify a submission made by any of the States concerned in the dispute. However, the Commission may consider one or more submissions in the areas under dispute with prior consent given by all States that are parties to such a dispute.'

ambulatory baselines versus fixed baselines. The ambulatory baseline approach emphasizes the inherent geographic connection of the baseline itself, providing an objective reflection of the geographical features between land and sea. According to this perspective, changes in the low-water line caused by SLR will result in corresponding adjustments to the baseline position (Sean, 2023). Conversely, the fixed baseline approach, as endorsed by the ILA, offers an alternative interpretation. It posits that once a coastal state records the baseline on a nautical chart, its position is determined solely by the recorded data and remains unaffected by the actual physical characteristics of the coastline (International Law Association, 2012).

Regardless of the ongoing academic debate surrounding baseline issues, this study has made several noteworthy findings:

1. The disappearance of offshore LTEs significantly influences the retreat of baselines for coastal states. Simultaneously, the legal status of water areas between offshore islands and the landmass will depend on the distance from the claimed maritime zone from the landmass following SLR.
2. The submarine ridges located at varying distances from coastal states are also affected by SLR. This impact may result in a change in the legal status of these submarine ridges, transforming them from their previous status as 'submarine ridges' to 'oceanic ridges'. Consequently, coastal states may face reduced natural conditions for asserting claims to extended the continental shelf beyond 200 NM.
3. Owing to geographical factors, within the overlapping EEZs of adjacent states, SLR may not uniformly shift coastal states' baselines toward land; instead, they could also move seaward. Consequently, this seaward movement may lead to either the reduction or expansion of overlapping areas between adjacent states. In the case of opposite states, if the maritime zones exceed 400 NM, changes in coastal countries' baselines due to SLR typically only affect the width of the high seas. However, if the maritime zones between opposite states are within 200 NM, the shifting of both states' baselines could potentially increase or decrease the overlapping areas of their EEZs, influenced by their respective geographical factors.
4. For CS overlap, states with favorable geographical conditions have a stable extension of their CS beyond 200 NM, experiencing a minimal impact from SLR. However, coastal states lacking natural prolongation geographical conditions can only assert the 200-NM distance principle, experiencing a relatively greater impact from SLR.
5. In the event of frozen areas, accurately assessing the status of coastal ice is crucial when selecting basepoints in ice-covered areas for baseline application. Additionally, activating special protection measures, particularly emphasizing the term 'ice sheet', is essential, with a prioritization placed on environmental preservation over resource exploitation, in line with the precautionary principle. In the absence of full scientific evidence recognized by the international community, the frozen clause can be used to put aside the boundary disputes in the heavy-ice region.

Finally, a new question raises whether the natural change belongs to the fundamental change in circumstances referred to in Article 62 (2)(a), or whether it has been changed in terms of the existence of the circumstances constituting an essential consent for the Convention parties mentioned in Article 62 (1)(a) of the 1969 Vienna Convention on the Law of Treaties (hereinafter the Vienna Convention). In short, when States have tried to delimit the maritime boundary due to the changing global natural context, which of Article 62 (1)(a) or Article 62 (2)(a) of the Vienna Convention should be applied? Whatever the ultimate choice is, global climate change will stimulate the development of the oceanic rules and the progress of international law.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

T-HT: Methodology, Investigation, Project administration, Supervision, Visualization, Writing – review & editing. WQ: Conceptualization, Data curation, Funding acquisition, Methodology, Resources, Validation, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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