

Maritime Summary Note n°228 – February 2021

« Marine aggregates : specific resources »

Sand is, alongside crushed rock and gravel, the second-largest resource extracted and traded worldwide by volume, ranking just behind water. It is an abundant material on the Earth's surface, but rather scarce as an exploitable raw material and unevenly distributed across the globe due to geological and geomorphological diversity. Marine aggregates originate from the disintegration of continental rocks under the effects of rainfall erosion, freeze-thaw cycles, landslides, and the mechanical action of glaciers—debris that is subsequently transported by wind or carried by rivers and streams down to the sea. This is an extremely long process and is non-renewable on the scale of a human lifespan. Global resources are estimated at 120 million billion cubic meters of sand, equivalent to approximately 192 million billion tonnes. It is estimated that 40 to 50 billion metric tonnes are extracted from quarries, pits, rivers, coastlines, and the marine environment each year worldwide. The construction industry consumes more than half of this annual volume (25.9 to 29.6 billion tonnes in 2012, according to UNEP, 2014) and could consume even more in the future. Aggregates are employed in construction (roads, railways, runways) and in manufacturing materials (concrete, asphalt, mortars). Sand is also present in the manufacturing of glass, ceramics, paint, electronic circuits, cosmetics, and laundry detergent. It can furthermore be a source of elements such as zirconium and titanium, or act as a component of industrial minerals like diamonds, sapphires, or garnets. As a raw material at the foundation of our economies, it raises environmental and climate stakes, conflicts of use, and issues of coactivity among environmental preservation associations, local elected officials, fishermen, and the extractive industry, alongside questions of global resource governance and potential diplomatic conflicts; the topics surrounding these tiny grains of sand are vast.

Contextual elements

There are several categories of aggregates depending on their particle size distribution—sand (finer) and gravel—and their shape: rounded (smooth) or crushed (angular). The vast majority are natural, but they can also stem from recycling. Finally, they vary according to their chemical properties, being either siliceous or limestone-based. Sand consists of grains with a diameter ranging between 0.06 mm and 2 or 5 mm depending on the classification system; anything below is silt and clay, while anything above is gravel.

These aggregates are described as alluvial (whether terrestrial or marine), meaning they result from the slow process of erosion (rounded aggregate). They can also be of massive eruptive and/or limestone origin (crushed aggregate) derived from quarries, or even from recycling (glass). Limitations on accessing terrestrial alluvial resources generate supply problems, including along certain coastal facades. Marine aggregates serve as a complement to aggregates extracted from terrestrial quarries for coastal zones or areas upstream of large estuaries thanks to inland waterways, though they hold no economic relevance outside these specific regions. The use of siliceous marine aggregates is highly sought after, notably for the rounded shape of their grains, which primarily serve in mixing concrete for construction. Within the Nantes region, they are also indispensable for market gardening. Limestone marine arrays (shell sands) are intended for agricultural soil conditioning, mainly in regions lacking terrestrial limestone deposits, such as Brittany. This helps limit reliance on phytosanitary chemical inputs.

Finally, marine aggregates can be utilized for coastal engineering works, such as beach nourishment or polder construction. The extraction and consumption of aggregates are intrinsically tied to regional economies and vary sharply across different world regions. Certain developing nations with weak regulations must face the outright theft of their resources, whereas European countries, and France in particular, possess a stringent legal framework governing exploration and exploitation. The extraction of

marine aggregates there is consequently regulated, monitored, and framed to take into account the resource, other maritime activities, and environmental stakes.

Aggregates on a global scale

The international trade of sand and gravel is increasing due to strong demand in regions lacking local resources, or in regions experiencing a massive real estate boom, often with a strong attraction toward coastal areas. China and India clearly stand out: two-thirds of global cement production occurs in China (58.5%) and India (6.6%). China distinguishes itself with an aggregate production rate of 14.3 tonnes per capita per year. It has increased its concrete utilization by 540% over the last 20 years. With 60% of Chinese citizens currently living in cities—and likely 80% by 2050—the need for new housing will be colossal. Even as domestic consumption rates begin to stabilize, Chinese and foreign investments in the infrastructure developments of the "New Silk Roads" (Belt and Road Initiative) will stimulate aggregate demand across approximately 70 countries.

There is very little public data available on extraction volumes, sources, and uses on a global scale. However, extracted aggregates are most frequently consumed regionally due to high transport costs. In emerging economies, the sand industry is fragmented and highly informal, relying on artisanal operations without genuine spatial planning or enforcement. This leaves a vacuum for the illegal extraction and trade of the resource, commonly referred to as the "sand mafia." One specific location focalizes these problems: the city-state of Singapore has seen its surface area expand by 20% from 1960 to the present day and could grow by another 100 square kilometers by 2030. This land reclamation (poldérisation) notably concerns new port facilities, as the city itself has scaled up. Having imported 517 Mt of sand over the last 20 years, Singapore is by far the largest importer of sand in the world, with a portion of this sand obtained illegally.

In Southeast Asia, the phenomenon has reached such proportions that Cambodia, Vietnam, Malaysia, and Indonesia have banned the export of their sand—often destined for their Singaporean neighbor—yet trafficking persists. Sand extraction has become a transboundary problem here. Singapore's sand suppliers frequently purchase sand from multiple intermediaries, making it difficult to trace its origin. This necessitates solutions focused on sand traceability and thorough due diligence across the entire supply chain.

Another region focalizing large-scale civil engineering works is the Persian Gulf. In the United Arab Emirates, port projects and giant skyscrapers are augmented by artificial islands, such as the Palm Islands and The World (a polder system meant to represent the globe, which lies abandoned today). As marine sand resources have become exhausted¹, certain Gulf countries like Saudi Arabia and the UAE have been forced to import sand from Australia.

In Morocco, half of the sand consumed—amounting to 15 Mt per year—originates from the illegal extraction of coastal sand. Expansive sandy beaches have been transformed into rocky landscapes between Safi and Essaouira, despite the existence of a coastal protection law. Since 2015, this legislation is supposed to prohibit extraction from all coastal dunes. Sand is frequently stripped from beaches to construct hotels, roads, and other tourism-related infrastructure. In certain areas, continued construction exacerbates the erosion phenomenon and contributes to the destruction of the beaches, which are the main natural attraction for visitors. Furthermore, this informal trafficking, often shielded by local authorities, can involve sand that is entirely unfit for construction due to the presence of iron and sodium chloride; this poses structural risks of embrittlement, oxidation, and ultimately a threat of building collapse. In Casablanca, a building collapse occurs on average every three months. Following Morocco's pattern, sand plundering also rages in Sierra Leone, Mozambique, India, and elsewhere across the globe.

These localized plunderings cause substantial environmental and societal damage. There are currently no level playing fields among governments, corporations, contractors, and subcontractors within the sand value chain. Smart resource management must involve a comprehensive resource mapping and genuine political will. The lack of knowledge regarding aggregate provenance remains a critical issue. Europe possesses substantial terrestrial and marine aggregate resources and has developed effective management systems for over 40 ans. This operational and regulatory framework is incomparable to those found in other regions of the world. Opportunities exist to learn from these European experiences,

¹ Desert sand is unsuitable for chemical reasons, as it lacks silicon dioxide compounds, is too fine and too smooth, and contains too much clay, iron oxides, and lime.

which can accelerate the transition of other countries toward more sustainable planning and regulatory policies.

The European situation and the French case

For the year 2018, and according to the 2019–2020 annual report of the European Aggregates Association, "*A Sustainable Industry for a Sustainable Europe*," the three largest extractors across all aggregate types combined are Germany (600 Mt) in first place, followed by France (430 Mt, tied with Turkey), and finally Poland (320 Mt). The marine aggregates branch represents only 1.9% of total European aggregate production (EU-28), standing at 57 Mt in 2018 compared to 82 Mt in 2009. The podium shifts significantly for marine aggregates alone, with the Netherlands in first place (16 Mt), followed by the United Kingdom (13.7 Mt), and Germany with 10 Mt extracted.

The aggregate extraction market is in the hands of a few large companies: on one hand, marine works specialists such as Boskalis (Netherlands), Van Oord (Netherlands), DEME (Belgium), and Jan De Nul (Belgium) [8]; on the other hand, materials companies like Sibelco (Belgium), Heidelberg Materials (Germany), CRH (Ireland), and Holcim (Switzerland). The highly active China Harbour Engineering Company (CHEC) must also be taken into account. In the United States, national legislation only allows domestic companies to operate within the marine sand extraction industry, and the (large) domestic sector is dominated by Great Lakes Dredge & Dock Co. In Europe, there is no common legal framework. Environmental impact assessments tend to become widespread as mandatory documents for granting extraction rights, even if all national frameworks do not strictly enforce them. France follows the recommendations for assessing and monitoring the effects of extraction advocated notably by the International Council for the Exploration of the Sea (ICES). Only France, Denmark, and Belgium have implemented dedicated monitoring of fisheries resources.

In France, according to the National Union of Aggregate Producers (UNPG), more than half of the aggregates extracted nationwide originate from massive rock. The annual production of marine aggregates in 2018 amounted to 6.2 million tonnes, representing 2% of French aggregate production. They originate entirely from open-sea operations, as extraction on beaches is strictly prohibited. Extraction within the minor beds (though not the major beds) of rivers and streams has been banned since 1993 to prevent hydraulic degradation. Aggregate production is strongly correlated with the economic climate. In France, 70% of the demand for aggregates relies on public procurement integrated into public land-use planning policies: demand for housing, collective facilities, commercial premises, and transport infrastructures (ports, airports, motorways).

By way of illustration, building a house consumes 100 to 300 tonnes of aggregates, a hospital requires 20,000 to 40,000 tonnes, and one kilometer of motorway consumes 30,000 tonnes. The 2008 economic crisis caused a 20% downturn in the building and civil engineering sector, leading to a collapse in the materials supply sector. Between 2008 and 2014, aggregate production plummeted by 44%. This activity contributes to the economic development of local territories and port activities, creating numerous jobs (700 direct jobs and 2,500 indirect jobs).

In the 1980s, the French shipping sector gathered around sixty sand carriers (*navires sabliers*), often with very low capacities (150 m³), alongside a few units of 500 m³ and 1,000 m³. Today, only four French sand carriers remain in service in France, owned by three companies:

- **DTM Sablimaris**², which extracts, transports, and markets marine aggregates, standing as the leader in France with 1.5 Mt per year.
- **CAN (Compagnie Armoricaïne de Navigation)**, which operates in northern Brittany for limestone sand and across the Atlantic.
- **STFMO (Société de Transports Fluvio-Maritimes)**, which is a subsidiary of *Les Sablières de l'Atlantique*, themselves 51% owned by the Charier Group.

For the English Channel facade, companies frequently charter vessels and rarely act as shipowners themselves.

France possesses around twenty active concessions located along the Atlantic and English Channel coastlines, totaling 140 km² of concessions. The majority of these concessions are located within French territorial waters (< 12 nautical miles).

² and whose main shareholder is the German HeidelbergMaterials Group.

The exploitation of marine aggregates is framed by specific legislation falling under both the Mining Code (*Code minier*) and the Environmental Code (*Code de l'environnement*). It is strictly monitored by State services at both the national (ministry) and local (regional administrations) levels. This exploitation can be preceded by an Exclusive Research Permit (*Permis exclusif de recherche* — PER) in order to define a perimeter of least impact for the operations. It helps feed scientific knowledge regarding the marine environment. Subsequently, in a second phase and if the site appears favorable, an application for exploitation (a concession) must be submitted. Securing a final concession authorization currently takes around 10 years and involves three administrative authorizations (which can be processed concurrently³), also requiring an environmental impact assessment and a public inquiry:

- A mining title (*titre minier*), which can be an exclusive research permit or a concession specifying the perimeter, duration, and authorized extraction volume. It is signed by the Minister in charge of mines following an official opinion from the Council of State (*Conseil d'État*). The duration of this concession can extend up to 50 years, but in practice, it typically lasts between 20 and 30 years.

- A public domain occupation authorization (*autorisation domaniale*) for the Maritime Public Domain (DPM), which specifies the fee amount for works carried out on the seabed of the DPM. It is signed by the Departmental Prefect or by the Grand Port Maritime (GPM) if it holds jurisdiction over the public domain.

- A prefectural authorization (or declaration) for the commencement of marine mining operations, detailing technical and environmental prescriptions and signed by the Departmental Prefect following local instruction.

These authorizations impose strict environmental monitoring of extraction operations. Environmental impact assessments are reviewed by Ifremer, which issues advisory opinions regarding bathymetric, morpho-sedimentary, benthic, and fisheries (*halieutique*) dimensions.

Cerema and BRGM are regularly consulted to perform modeling and analysis regarding potential impacts on the coastline (*trait de côte*). These studies also serve to mitigate conflicts of use with other socio-economic activities, such as commercial fishing, while taking adjacent Natura 2000 protected sites into account. An ecosystem-based approach is heavily prioritized. This monitoring data is periodically presented during oversight commissions (*commissions de suivi*) composed of state services, scientists, environmental associations, marine users, and maritime professionals.

Marine aggregate extraction is subject to numerous controls and regular balance sheets, including the continuous electronic logging of extraction tracks, alongside annual and five-year monitoring reports. It strictly adheres to the standard environmental sequence: avoid, reduce, compensate (ERC). A baseline environmental assessment of the exploitation site is conducted beforehand, followed by continuous tracking throughout the operations based on a five-year timeline. This framework can trigger the implementation of specific operational strategies and targeted scientific monitoring. The primary goal of this oversight is to verify the total absence of impact in terms of coastal erosion or sediment contamination (such as mud layers), and to limit disturbances within the water column (turbidity), changes to hydrodynamics (effects on wave propagation), and impacts on benthic and demersal fish species (notably by avoiding nursery grounds and spawning areas).

In France, the main ports of discharge for marine aggregates are: Dieppe, Rouen, Le Havre, Brest, Lorient, Montoir-de-Bretagne, Les Sables-d'Olonne, La Rochelle, and Bordeaux. The aggregates are subsequently processed for commercialization across approximately thirty dedicated facilities distributed along the coastline.

Focus on recycling

Aggregates derived from recycling in 2018 amounted to 321 Mt within the EU-28, representing 10% of total EU production. While situations vary significantly from one State to another, France leads the way with 112 Mt, accounting for 27% of the EU's total recycled production. Conversely, other Member States such as Italy, Croatia, or the Czech Republic report no aggregates derived from recycling. Yet, Directive 2008/98/EC of the European Parliament and of the Council of November 19, 2008, on waste, mandates that Member States must take the necessary measures to ensure that at least 70% of construction and demolition waste is reused, recycled, or recovered through backfilling, a target effective since 2020. The European Green Deal will further accelerate strategies for constructing more sustainable buildings,

³ Decree No. 2006-798 of July 6, 2006, which regulates the content of applications and procedures within a single unified text.

focusing on increasing the energy efficiency of materials and reducing climate impacts throughout the entire lifecycle of buildings.

Marine aggregates are essentially reserved for local applications within coastal territories and upstream of large estuaries. In fact, their price doubles every 30 kilometers due to transport costs, which limits the catchment area (*zone de chalandise*) to 60 kilometers from the points of discharge. Maritime and inland waterway transport represents a genuine alternative: it facilitates the supply required by certain urban agglomerations (Paris, Rouen, Nantes, Bordeaux, Rochefort). It reduces road traffic, noise pollution, gas emissions, and, above all, energy consumption. Transporting 1,500 tonnes of sand would otherwise require approximately 60 trucks. Marine aggregates meet 20% to 60% of the requirements of coastal departments. In Loire-Atlantique, they cover more than 70% of sand requirements, while between Le Havre and Fécamp, they meet 80% of the demand.

Aggregates, whether terrestrial or marine, form the very foundation of our modern societies. The extractive industry responds to a demand. This demand must be integrated into a sustainable model focused on rationing and limiting our consumption of materials and available land. New construction methods tailored to regional specificities can alleviate the reliance on a "concrete-only" culture; the optimization and recycling of materials through R&D into new processes must be encouraged, and enhanced scientific knowledge to reconcile economic development with environmental preservation are all avenues to be pursued and sustained.

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