Flux and fate of the Yellow (Huanghe) River–derived materials to the sea: impacts of climate change and human activities

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1. Introduction

The Yellow River (Huanghe) is the second-longest river in China after the Yangtze and the sixth longest in the world at an estimated length of 5,464 km. It originates in Kunlun Mountains in Qinghai Province in western China, flows eastward through nine provinces, and empties into the Bohai Sea (Fig. 6.1). The Yellow River basin drains 752,000 km², which supports more than 100 million people, and historically has been called the “Mother River” and “the cradle of Chinese civilization.”

The Yellow River’s upper reach starts from its source in the Bayan Har Mountains and ends at Hekou Town of Inner Mongolia just before the river turns sharply to the south (Fig. 6.1). This upper reach portion of the river flows mostly through pastures, swamps, and knolls, resulting in a clear and steady flow of water and minor sediment contribution to the Yellow River overall. Therefore, this segment contributes less than 8% of the river’s total sediment load, even though it covers 51.4% of the total basin area. The middle reach starts at Hekou Town and ends at the city of Zhengzhou in Henan Province. In the middle reach, the Yellow River passes through the Loess Plateau (Fig. 6.1), where substantial erosion takes place. The middle section covers 45.7% of the total drainage; however, it contributes 92% of the river’s sediment discharge. In the lower reach, from Zhengzhou to the sea, a distance of 786 km, the river is confined within a levee-lined course as it flows northeast across the North China Plain before emptying into the Bohai Sea. This section covers only 3% of the total basin. The low gradient and resulting reduction in river velocities in the lower reach results in channel deposition of large amount of silt, elevating the river bed and creating the famous “river above ground.” In the beginning of the lower reach, near Kaifeng city in Henan Province, the Yellow River bed, confined by levees, is perched 10 m above the surrounding floodplain (Wang et al. 2006, 2007; Wikipedia 2012).

The area of the Yellow River’s watershed is only one-eighth of that of the Amazon River; however, the middle reach basin is dominated by the highly erodible Loess Plateau farmlands and bare (deforested) land. Based on the land cover data from ESA GlobCover in 2009, 65% of the modern Yellow River basin is cropland and 18% is bare land (Fig. 6.2). Silt input along the middle reaches lends the river a distinctive yellowish brown color, giving the Yellow River its name. However, before A.D. 200, the river was called Dahe, which means “Large River.” The river was not muddy at that time (Saito and Yang, 1994). Its sediment discharge was calculated as only 10% of its last hundred-year level (Milliman et al. 1987; Liu et al. 2002). The large amount of clay, silt, and sand discharging...
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Figure 6.1. The Yellow River watershed in north China. The river originates from the Qinghai-Tibet Plateau in the west, flows through the Loess Plateau in the middle, and empties into the Bohai Sea in the east. The Hydrological Station of Lijin is about 100 km upstream from the river’s mouth. Two reservoirs, Longyangxia and Liujiaxia, are located in the upper reaches; the other two, Sanmenxia and Xiaolongdi, are in the middle reaches.

Figure 6.2. The Yellow River basin landcover distribution, which indicates the predominated croplands (65%) and bare areas (18%). Analysis was done in ArcGIS based on the downloadable data from ESA GlobCover 2009.
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Figure 6.3. (A) Yellow River’s annual water discharge and sediment load at Lijin Station from 1950 to 2008; (B) annual sediment concentration at Lijin Station, the line represents a linear trend from 1950 to 2008, showing the overall decreasing after large reservoirs being built.

into the river also makes the modern Yellow River one of the most sediment-laden and turbid rivers in the world. Although it has been decreasing in the last decade, the sediment concentration of the Yellow River averages 20–40 kg/m$^3$ (Fig. 6.3), compared with 2.8 kg/m$^3$ for Indus, 0.2 kg/m$^3$ for the Amazon, and 0.8 kg/m$^3$ for the Mississippi (Milliman and Farnsworth 2011).

Overall, the historic sediment load of the Yellow River since 1919 has been about 1.6 $\times$ 10$^9$ tons/yr (Fig. 6.3), of which perhaps at least 25% (0.4 $\times$ 10$^9$ tons/yr) is deposited in the lower river reach channel, raising the bed about 10 cm/yr (Ministry of Water Resources [MOWR], 2001). The highest recorded annual load of silt discharged into the Yellow River is 3.91 $\times$ 10$^9$ tons in 1933. The highest suspended sediment concentration was recorded in 1977’s flood at 920 kg/m$^3$. A large portion of this sediment was deposited in the nearly flat and slow-moving lower reaches of the river. As a result of the perching of the channel above the floodplain, during the flood seasons, the river often broke through its confining levees and established a new course. In the past 2000 years, the Yellow River has had at least 26 major course changes. The river mouth on 100-year timescales shifted hundreds of
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Figure 6.4. The yearly distribution of Yellow River no-flow dried-up days from 1972 to 2012. Starting from late 1999, the YRCC began to manage the river flow, mainly through adjusting the Xiaolangdi Reservoir, and since then, the river has never been dried up.

kilometers between Jiangsu and Shandong provinces (Figs. 6.1, and 6.5), causing discharge to vary between the Yellow and Bohai Sea (MOWR, 2001).

Monitoring observations at the Lijin Hydrological Station, about 100 km upstream from the river mouth (Fig. 6.1), show that before the 1980s about $1.1 \times 10^9$ tons/yr of sediment was discharged into the Bohai Sea (Qian and Dai 1980). Other than the Amazon and Ganges-Brahmaputra rivers, no other rivers in the world are known to discharge more than $0.5 \times 10^9$ tons/yr to the ocean. As a result, the large sediment load of the Yellow River has created a massive flood plain in northern China, two prominent proximal deltas in the Shandong and Jiangsu coasts, and a thick distal subaqueous mud accumulation in the Yellow Sea shelf (Alexander et al. 1991; Liu et al. 2004; Yang and Liu 2007). Therefore, the Yellow River, together with the Yangtze, is thought to account for ~10% of the global sediment flux to the oceans (Milliman and Meade 1983; Milliman and Syvitski 1992).

In the past 30 years, however, due to natural and anthropogenic impacts, the volume of water and sediment discharged by the Yellow River to the Bohai Sea has been steadily decreasing. For example, for several years in the early 1960s, annual water discharge was greater than 90 km$^3$/yr, and prior to 1970, discharge was consistently greater than 25 km$^3$/yr (Fig. 6.3A). In contrast, during the last 20 years, annual water discharge has averaged less than 25 km$^3$/yr (Wang et al. 2007, 2011). Moreover, in 1997, no water flowed into the sea for a total 226 days (Fig. 6.4) (Yang et al. 1998). This decrease in sediment delivery to the coast has caused a series of problems, including delta subsidence, flooding, relative sea-level rise, coastal erosion, and marine ecosystem deterioration (Bianchi and Allison 2009; Syvitski et al. 2009).

In this chapter, we will review the historical changes of Yellow River water and sediment discharges. Included is a discussion of the causes and impact of this variability and the fate of river-derived sediments into the sea, including its distribution, transport processes, and strata thicknesses on adjacent Bohai and Yellow Sea continental shelves.
2. Historical changes of the Yellow River water and sediment discharge

2.1. Sediment fluxes on the millennial scale

Throughout its history, the Yellow River has experienced frequent devastating floods, levee breaching, and course changes, owing to seasonally distributed water discharge, high sediment load, and an elevated river bed (Yang et al. 2000). One of the major results of these changes is the formation of the North China Plain, the largest alluvial plain and lowland area of eastern Asia, covering 410,000 km². This fertile soil has undergone intense cultivation since early Chinese history and is considered the cradle of Chinese culture and civilization.

Previous studies show that in the last 10 kyr (Holocene period), the Yellow River has changed its lower reach course more than 10 times, both regionally (flowing into the Bohai Sea or South Yellow Sea) and locally (e.g., emptying into the northwestern or southwestern Bohai Sea) (Fig. 6.5). In the beginning of the Holocene, at 9–7.5 kyr before present, the Yellow River emptied into the South Yellow Sea (Fig. 6.5, lobe 1), forming a 20-m-thick offshore delta accumulation (Yang 1985; Shi et al. 1986; Milliman et al. 1987, 1989). The estimated annual sediment load to the sea during
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Table 6.1. Holocene sediment and accumulation in the western bohai and yellow seas

(see Fig. 6.5 for locations)

<table>
<thead>
<tr>
<th>Location</th>
<th>9–7.5 kyr B.P.</th>
<th>7.0–1.0 kyr B.P.</th>
<th>A.D. 1128–1855</th>
<th>A.D. 1855–Present</th>
<th>9ka–Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYS offshore (Lobe 1)</td>
<td>200</td>
<td>500</td>
<td>250</td>
<td>108</td>
<td>300</td>
</tr>
<tr>
<td>BS nearshore (Lobes 2–9)</td>
<td>240×10⁹</td>
<td>600×10⁹</td>
<td>300×10⁹</td>
<td>140×10⁹</td>
<td>360×10⁹</td>
</tr>
<tr>
<td>SYS nearshore (Lobe 10)</td>
<td>0.16×10⁹</td>
<td>0.1×10⁹</td>
<td>0.43×10⁹</td>
<td>0.9×10⁹</td>
<td>0.04×10⁹</td>
</tr>
<tr>
<td>BS nearshore (Lobe 11)</td>
<td>0.23×10⁹</td>
<td>0.14×10⁹</td>
<td>0.61×10⁹</td>
<td>1.3×10⁹</td>
<td></td>
</tr>
<tr>
<td>YS offshore (Distal mud)</td>
<td>0.23×10⁹</td>
<td>0.14×10⁹</td>
<td>0.61×10⁹</td>
<td>1.3×10⁹</td>
<td></td>
</tr>
</tbody>
</table>

Modified from Liu et al. 2002.

this time was 0.16×10⁹ tons/yr (Liu et al. 2002), which agrees quite closely with inferred Yellow River sediment fluxes prior to agricultural activity on the loess plateau of northern China (Milliman et al. 1987; Saito and Yang 1994). Following a northward shift in course around 7–7.5 ka, the Yellow River continued to discharge into the Bohai Sea until a.d. 1128. During this approximately 6-kyr interval, it formed at least eight deltaic superlobes (Fig. 6.5, lobes 2–9) (Xue 1993; Saito et al. 2000), accounting for a total sediment volume/mass of 500 km³/600×10⁹ t (Table 6.1). The annual Yellow River sediment flux during this period would have been about 0.11×10⁹ tons/yr (Liu et al. 2002). A section profile crossing lobes 2, 8, and 11 indicates that the initiation of the Yellow River delta in the western Bohai at ~6–5 ka b.p. formed the first Lijian delta super lobe, about 150 km west of the modern coastline (Fig. 6.6) (Xue. 1993).

From a.d. 1128 to 1855, the Yellow River again discharged southward onto the Jiangsu coast and emptied into the South Yellow Sea (Fig. 6.5, lobe 10). In this 730-yr interval, approximately 250 km³ of sediment was deposited along the Jiangsu coast, which equates to a mean annual sediment load of 0.43×10⁹ tons/yr, reflecting enhanced erosion from increased agricultural activity in the loess hills of northern China. As a result, in the western Bohai Sea, there was a sedimentary facies gap in the delta lobe between 1128–1855 (Fig. 6.6). The last major shift of the Yellow River to the northward

Figure 6.6. A section profile crossing the lobes 2, 8, and 11 shows the time lines of the Yellow River deltaic progradation since the middle Holocene (after Xue et al. 1993).
Figure 6.7. Historical coastline changes of the modern Yellow River Delta from 1976 to 2006.

pathway occurred in a.d. 1855 (Fig. 6.5, lobe 11; Fig. 6.6). Assuming an annual riverine sediment load of $0.9 \times 10^9$ tons/yr (Milliman and Meade 1983), in the years between 1855 and the present, an estimated $140 \times 10^9$ tons (or 108 km$^3$) (Table 6.1) of sediment passing the Lijin Hydrographic Station (Fig. 6.1) accumulated on the prograding delta and offshore. Overall, the 11 documented shifts in the Yellow River’s path in the latter half of the Holocene have collectively deposited nearly 500 km$^3$ of sediment in the nearshore of the Yellow Sea, 300 km$^3$ offshore, and about 600 km$^3$ in the Bohai Sea (Fig. 6.5; Table 6.1).

2.2. Sediment fluxes on the decadal scale

After the last major northward shift of its course from the Jiangsu to the Shandong provinces in 1855, the Yellow River has been discharging into the western Bohai Sea. From 1855 to 1976, the Yellow River created 2058 km$^2$ of land, with a progradation rate of 24 km$^2$/yr. From 1976 to 1992, the net land area of accretion was about 364.4 km$^2$ with a rate of 22.8 km$^2$/yr (Fig. 6.7) (Li et al. 2000; Li and Chen 2003). However, from 1992 to 2000, the net land progradation was only 37 km$^2$, with a rate of 4.1 km$^2$/yr (Chang et al. 2004). Based on historical runoff and sediment load data from 1955 to 1989, and their relationship with deltaic land changes, Xu (2002) concluded that, to keep the delta and coastal zone stable in terms of land loss or gain would require a sediment discharge of about $280 \times 10^6$ tons/yr. More recent data (1976–2002), analyzed by Cui et al. (2006), indicated that to prevent the delta and coastal area from retreating, the equilibrium point involves an annual runoff
2. Historical changes of the Yellow River water and sediment discharge

of 13.5 km$^3$, a sediment load of $350 \times 10^6$ t, or a carrying capacity of 19.64 kg/m$^3$. The Yellow River (Fig. 6.3) at the Lijin Station between 2000 and 2005 had a mean water discharge that was reduced to 12.24 km$^3$/yr, a sediment load reduced to $160 \times 10^6$ tons/yr, and a sediment concentration that was only 10.5 kg/m$^3$ (Wang et al. 2007).

The Yellow River’s oft-cited sediment load of $1.1 \times 10^9$ tons/yr given by Qian and Dai (1980) is based on data collected between the 1950s and 1970s, when the river’s water and sediment discharge were generally high (Yang et al. 1998) (Fig. 6.3). However, since the 1950s, the Yellow River basin has experienced a series of dramatic changes by both climate shifting and human activities, such as construction of large dams and reservoirs, effective soil conservation, and regional climatic changes. The impacts of the preceding changes have caused stepwise decreases in the annual water and sediment discharges to the sea (Fig. 6.3) (Yang et al. 1998; Walling and Fang 2003; Xu 2003; Wang et al. 2006, 2007, 2010, 2011).

2.3. Causes of the recent decrease of the water and sediment discharge

One of the major causes of the sediment load stepwise decrease is the operation of a series of large reservoirs and dams. From 1960–2000, more than 300 reservoirs had been constructed over the Yellow River basin; 24 of them are considered large reservoirs with individual storage capacities over $1 \times 10^8$ m$^3$. Of these, at least four major reservoirs (Sanmenxia, Liujiaxia, Longyangxia, and Xiaolangdi) have been built over the main channel, two in the upper reach, and two in the middle reach (see Fig. 6.1). These dams have had a dramatic influence on water regulation (floods) and sediment retention (Wang et al. 2006, 2007, 2011). For example, after the first large dam (Sanmenxia) was built in the middle reach in the 1960s, the reservoir had already trapped more than $7.7 \times 10^9$ tons of sediment up to 1973 (Fig. 6.3). After the completion of the Liujiaxia Reservoir in 1968, the annual sediment load delivered from the upper reaches decreased from $0.17 \times 10^9$ to $0.1 \times 10^9$ tons. After the Longyangxia Reservoir was completed in 1986, the annual sediment load from the upper reach decreased again to about $0.04 \times 10^9$ tons. Since the completion of the Xiaolangdi Reservoir in 2000, the annual sediment load at Lijin Station has decreased to $0.15 \times 10^9$ tons, only ~10% of the 1950s level (Fig. 6.3) (Wang et al. 2011; Wang et al. 2013; Chapter 5).

In addition to the sediment retentions by large dams and reservoirs over the basin, the soil conservation program initiated in the late 1970s and early 1980s has caused a sharp decrease in the drainage basin sediment yield. In the 1950s, the Loess Plateau in the middle reaches discharged an estimated $1.6 \times 10^9$ tons of sediment into the river. By the 1970s, this number increased to $2.2 \times 10^9$ tons due to deforestation and agricultural activities (Zheng et al. 1994). However, the sediment load at Lijin station decreased to $0.76 \times 10^9$ tons in early 1980s and dropped further to $0.36 \times 10^9$ tons in 2000–2008 (Fig. 6.3A) (Wang et al. 2011; Wang et al. 2013; Chapter 5).

At the same time, the decline in water discharge since 1965 (Fig. 6.3A) is most likely caused by a reduction in rainfall and increased use of the river water (Yang et al. 1998). During the past decade, rainfall in the middle and upper reaches of the Yellow River basin has dropped more than 12% compared with the 1950s (National Environment Protection Bureau 1997), but the agricultural irrigation has increased by a factor of five since 1950. In 1999, water diverted from the river served 140 million people and irrigated 74,000 km$^2$ of land. By 2000, more than 39 km$^3$ water was used in
the Yellow River basin: nearly 80% of that for agriculture, about 12–13% for industry, and 7–8% for drinking water (Yellow River Conservancy Commission 2002). The increased population and rapid economic development in northern China have been a major control on increasing water consumption in the Yellow River basin: total water use increased an estimated 21% between 1990 and 2000 (Helweg 2000).

2.4. Impacts of the recent-year water discharges and sediment loads decreasing

As Figure 6.3 shows, in the past decades, both water and sediment discharge have been regularly decreasing. These decreases have caused some severe impacts on the Yellow River delta environment and coastal stability, such as coastal erosion flooding, saline intrusion, and so forth.

One evident change is the decreasing of the delta progradation rate, or coastline retreat in the delta area with severe erosion. Based on the multiyear satellite images analysis, the historical changes of the modern Yellow River delta coastlines have been reconstructed (Fig. 6.7). Clearly, the Yellow River delta had been progradating much faster between 1976 and 1985, when the annual sediment load was still between 0.5 and 1.0 × 10⁹ tons. After 1985, the annual sediment load basically was below 0.6 × 10⁹ tons, the rate of extending to the sea decreased. In most recent years, the south branch of the modern river delta has gradually retreated since 1996, and the north branch has sharply retreated in the year 2006.

Further analysis of the relationship of the historical Yellow River mean annual sediment load and annual increased deltaic land indicates that, when the annual sediment load is below 300 × 10⁶ tons, there will be a negative gain of the new land (Fig. 6.8). Basically, in the last decade, with the extreme low annual sediment load (<200 × 10⁶ tons), the Yellow River delta has no new land being created; instead, some sections have been sharply eroded, particularly in the south branch.

With the gradual decreasing sediment load by passing the Lijin Station, not only has the delta growth slowed down or stopped, but also the amount of sediment discharged in to the offshore has also gradually decreased (Wang K.R. et al. 2007). Its impacts to the marine environment and sediment depositional and biogeochemical processes need to be studied in the future.

3. Fate of yellow river sediments in the Bohai and Yellow Seas

3.1. Rapid accumulations near the river mouth: proximal deltaic depocenter

Since the postglacial sea level reached its present position at approximately 7 kyr, the modern Yellow River delta has begun to form in the western Bohai Sea (Xue 1993; Saito et al. 2001). The enormous prehistorical Yellow River sediment discharge of ~1 × 10⁹ tons has created a large subaerial delta plain, with an area of ~8,000 km² and up to 20 m thick (Figs. 6.5 and 6.6).

One unique feature of the Yellow River relative to other large rivers, such as the Amazon, Yangtze, and Mississippi, is its extremely high sediment concentration (often greater than 40 g/L, or kg/m³), which makes it possible to form hyperpycncal flows where the river meets the ocean (Mulder and Syvitski 1995). During the summer flooding season, highly turbid gravity flows have been observed off the Yellow River mouth (Wright et al. 1988, 1990; Wang et al. 2010b), and most of the fluvially
Figure 6.8. The relationship of the historical Yellow River mean annual sediment load and annual increased deltaic land (Data collected from Jiang M.X. et al. 2004; Li X.N. et al. 2001; Li Y.Z. et al. 2012, Wang K.R. et al. 2007). Basically, when the annual sediment load is below $300 \times 10^6$ tons, there will be a negative gain of the new land.

derived sediment (70%) appears to remain trapped within 15 km of the modern deltaic shoreline (Qin and Li 1986; Bornhold et al. 1986; Martin et al. 1993; Wright et al. 2001).

In the winter months, the Yellow River delivers only 15% of its annual water discharge and less than 10% of its sediment load (Milliman and Farnsworth 2011; Yang et al. 2011). However, under the prevailing winter monsoon and intensified wave conditions, the previously deposited Yellow River sediment, which mainly accumulates during the summer flood seasons, is partly resuspended and eroded, forming an extensive suspended sediment plume around the Shandong Peninsula (Fig. 6.9). Field data indicate that suspended sediment concentration in the winter of 2006 was 1.7 to 27 times higher than the 2007 summer value, and the suspended sediment flux was 2 to 122 times higher in the winter than summer (Yang et al. 2011). This indicates that Yellow River sediment was resuspended and transported offshore beyond the delta, mainly in the winter season. Numerical modeling results also support the concept that a dominant portion of the remobilized sediment is carried out of the Bohai Sea into the Yellow Sea through the Bohai Strait (Jiang et al. 2000, 2004; Li et al. 2010) (Fig. 6.9). Based on shipboard and satellite observations of suspended materials, Bi et al. (2011) concluded that the annual sediment flux through the southern Bohai Strait is about $40 \times 10^6$ tons/yr,
3.2. Longshore transport to the Yellow Sea: distal mud depocenter

In addition to the proximal depocenter on the delta, previous studies have shown that in the past 7,000 years, more than 30% of the total Yellow River sediment has been resuspended and transported out of the Bohai Sea into the Yellow Sea (Liu et al. 2002, 2004; Yang and Liu 2007). The North Yellow Sea has been assumed to be an escape pathway (Milliman et al. 1989; Alexander et al. 1991). Based on limited observations, Qin and Li (1986) indicated that approximately $6-8 \times 10^6$ tons/yr of sediment escapes from the Bohai to the Yellow Sea (Qin and Li 1986; Martin et al. 1993). Based on the seismic surveys and $^{14}$C dating of the cores on the Yellow Sea shelf, Liu et al. (2004) concluded that the average sediment accumulation in the Yellow Sea shelf is $33 \times 10^6$ tons/yr.

Data from geophysical seismic surveys, coring, and suspended matters observations indicate that the modern Yellow River–derived sediment has transported out of the Baihai Sea, via the North Yellow Sea, and reached the central Yellow Sea, about 700 km from the river mouth (Yang and Liu 2007; Liu et al. 2009). This along-shelf distributed distal clinoform has been deposited since the middle Holocene sea level highstand, mainly by the resuspended Yellow River sediments carried alongshore by the coastal current and interacting with local waves, tides, and upwelling. Around the eastern side of the Shandong Peninsula, there is a 40-m thick distal mud that has accumulated on the middle shelf at a water depth of approximately $-40$ to $-80$ m (Figs. 6.10 and 6.11). $^{14}$C dating and geochemical features of several deep cores have linked this deposit to the Yellow River and indicate that it has formed since the last sea-level rise and transgression in the middle Holocene (Liu et al. 2007). Over the past 7,000 years, analysis of the size distribution of sediments in this deposit in the Bohai and Yellow Sea indicates that nearly 30% of the Yellow River–derived sediment has been resuspended and transported out of the Bohai Sea into the North and South Yellow Sea. Overall,
4. Conclusions

The Yellow River is one of the most important rivers in the world in terms of water discharge and sediment load to the sea; its basin supports more than 100 million people and vast agricultural enterprises, and its delta region also contains a very rich oil field. Understanding the historical changes of the Yellow River’s sediment fluxes and fates of its sediment is critical to China both economically and politically.

In the past 7 kyr, the Yellow River has discharged more than $1.500 \times 10^9$ tons of sediment to the sea. In addition to forming a large subaerial and subaqueous delta (>8,000 km$^2$) proximal to the river mouth(s), at least 30% of the total sediment delivered during this period is estimated to have been transported alongshore out of the Bohai Sea along the Shandong peninsula, ultimately accumulating as a thick distal mud lobe on the South Yellow Sea continental shelf (Figs. 6.10 and 6.12).
Figure 6.11. Selected seismic profiles indicate the distribution of the Yellow River–derived sediment. Seismic profiles show the Yellow River’s longshore-transported distal mud accumulation prograding from the Bohai Sea to the North Yellow Sea (A), then continue to the South Yellow Sea (B). The Chirp profile show the abandon old Yellow River deltaic deposits in the south Yellow Sea (C), most likely the one formed at A.D. 1128–1855.

Figure 6.12. A conceptual model of the distribution and fate of the Yellow River–derived sediment to the coast and sea. Two dash circles represent the proximal depocenter near the river mouth and the remote nearshore depocenter hundreds of kilometers away from the river mouth (after Liu et al. 2009).
Over the last 60 years, global and regional climate change, along with human activities, has caused major transformation of the river system in the alluvial valley and at its mouth. The building of large dams and reservoirs, an increased demand for water from growing industry, agriculture, and domestic needs have caused a stepwise decrease in water and sediment loads reaching the sea. As a result, the Yellow River delta is experiencing a paradigm shift from rapid progradation to slow growing or severe erosion (Figs. 6.7 and 6.8). This decrease in sediment delivery to the coast has not yet translated into an observable decrease in alongshore sediment delivery to the distal depositional area, but it will not be surprising to see changes in the rate and nature of materials in the near future. Additional monitoring networks and programs will be necessary in the future to document the impact of human influences on this dynamic fluvio-deltaic system – both onshore and offshore.

References


References


