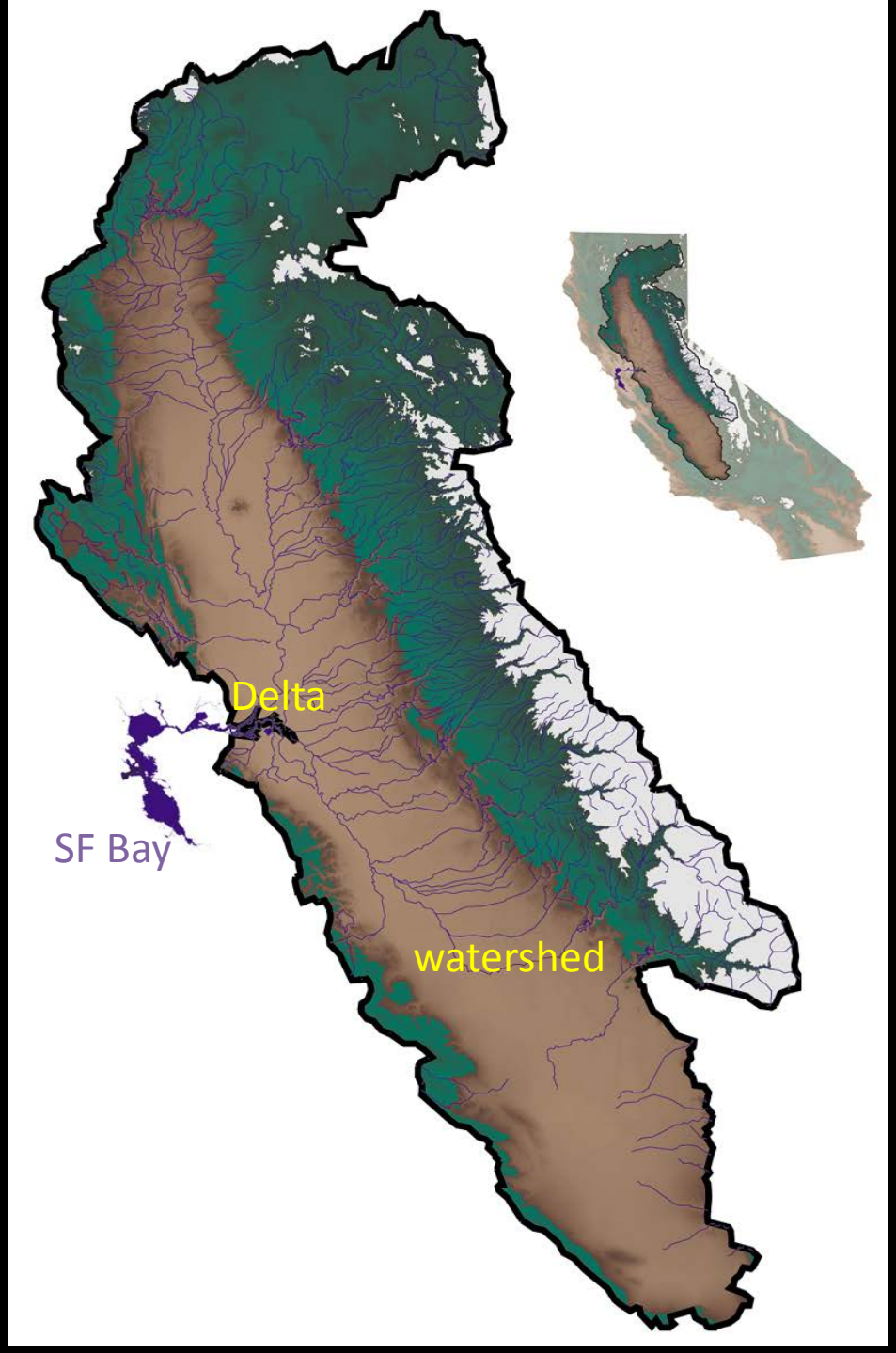


Dams and their downstream effects in California

All large rivers are dammed

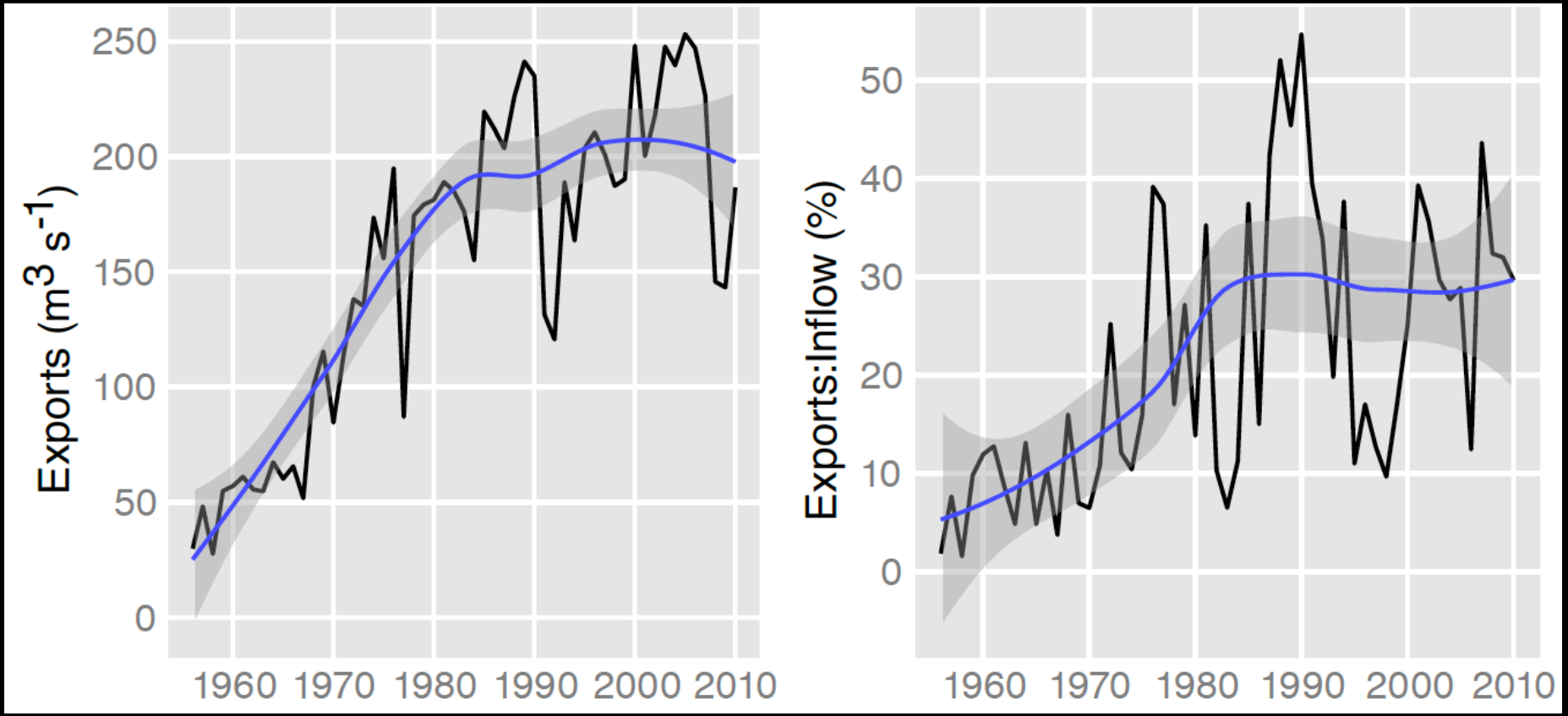

INFLOW
Delta
SF Bay

Dams for flood protection & water management

Effects on freshwater inflow to the estuary

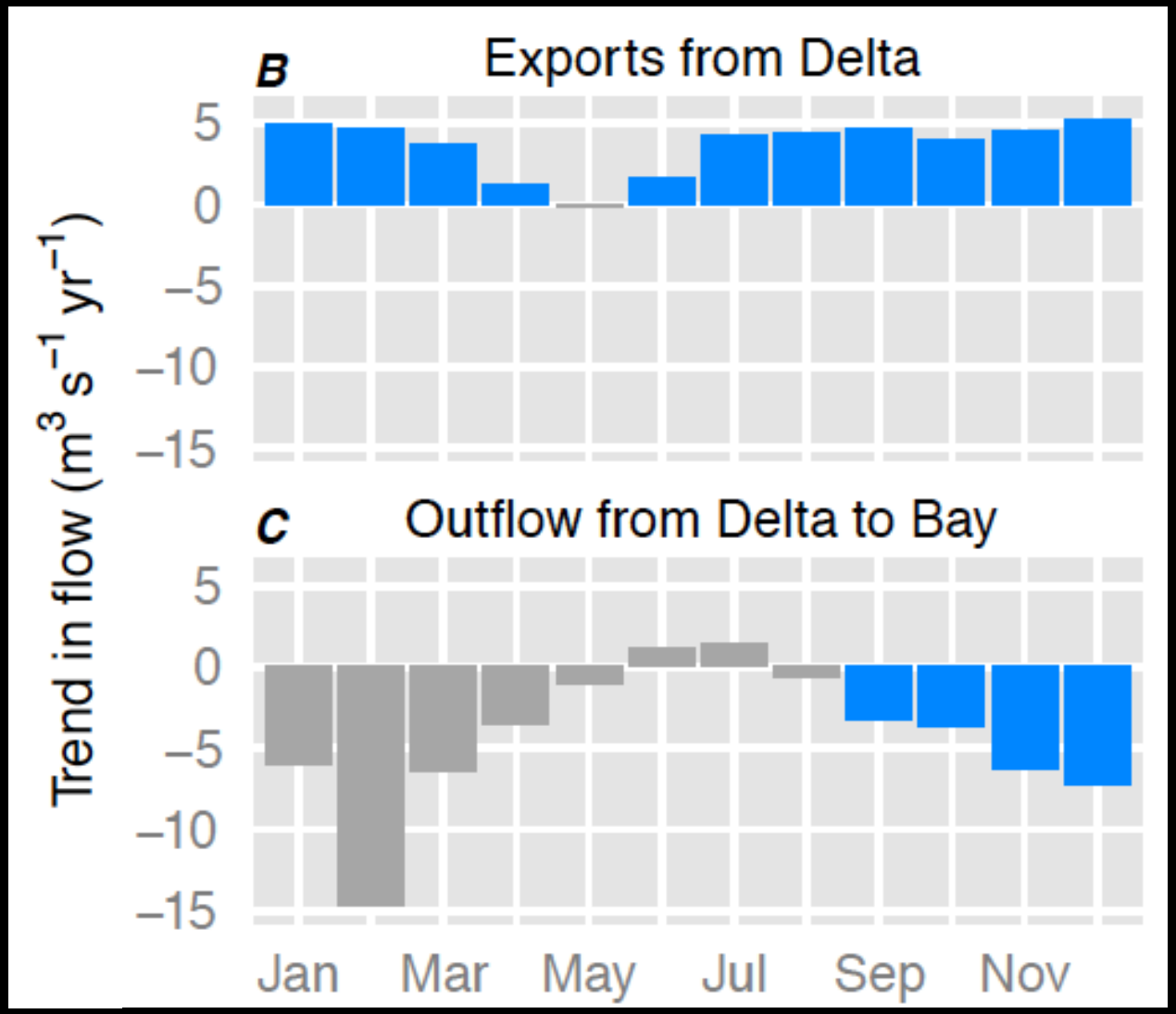
Export Increased Steadily after 1956

Now about 30% of inflow



Cloern & Jassby 2012

Trends by Month (1956-2010)



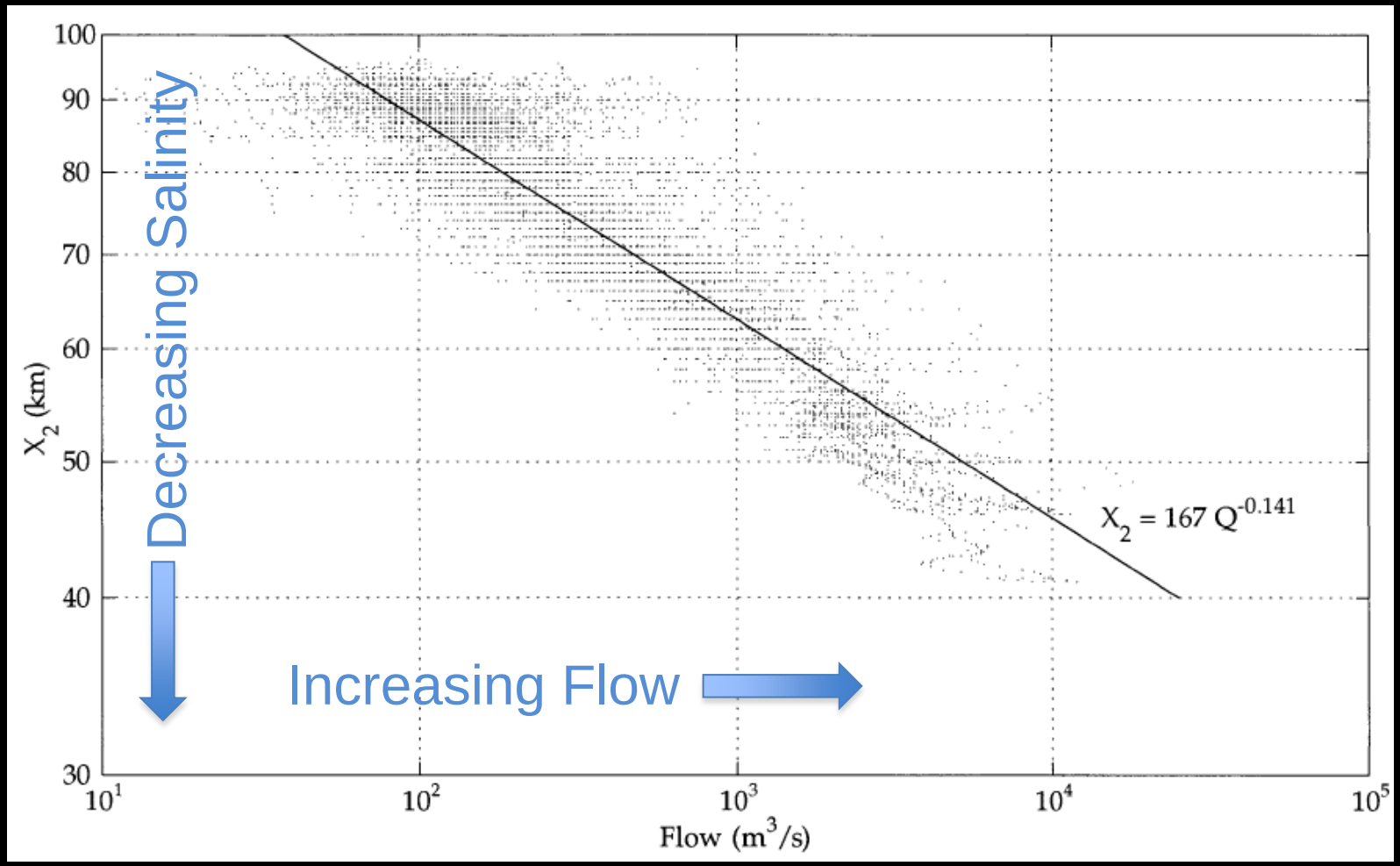
Exports have increased significantly each month except May

Outflow has decreased significantly, September through December

Cloern & Jassby 2012

X2 – an index of salinity distribution

Outflow determines salinity in the estuary, measured as X2



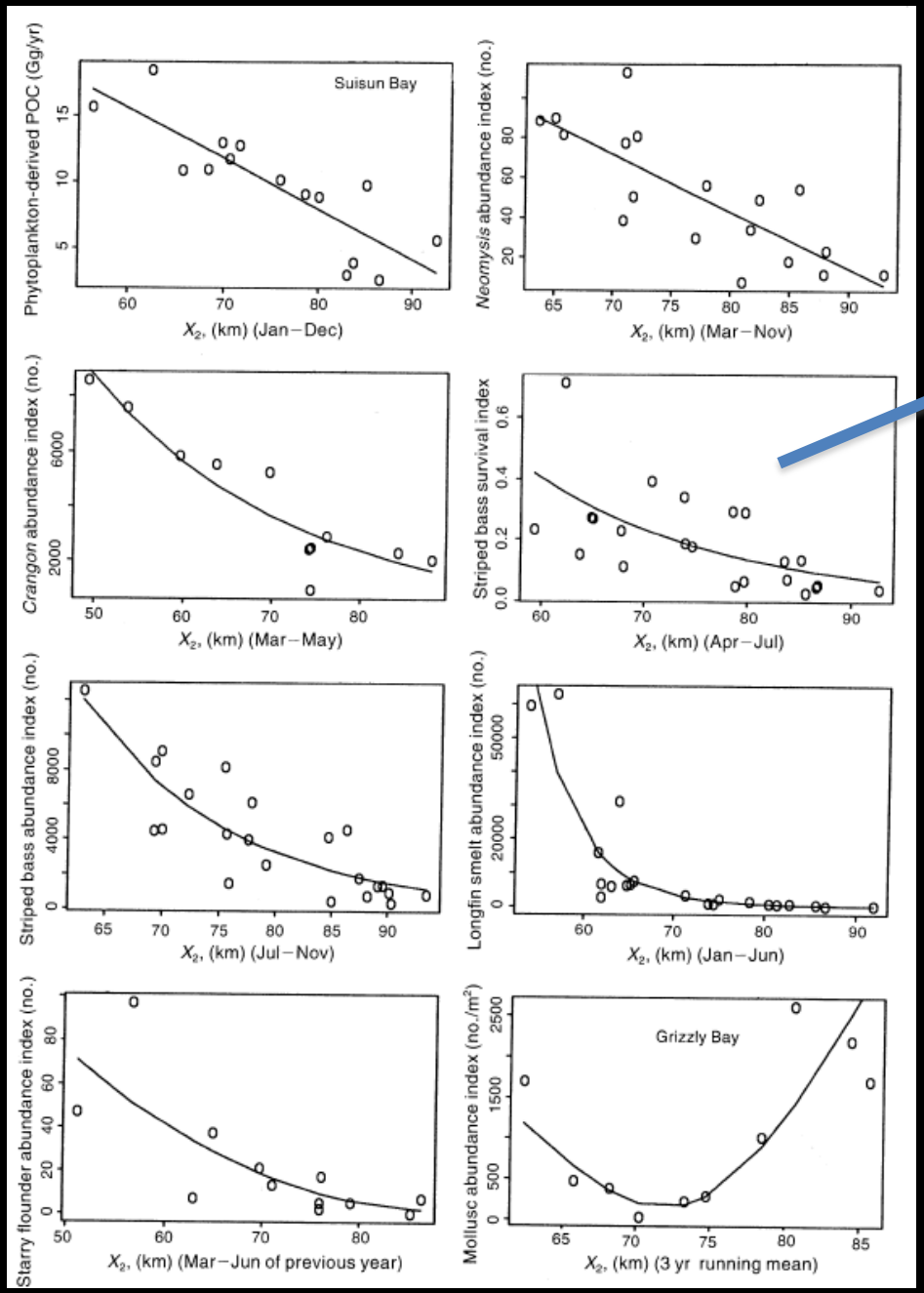
Monismith et al. 2002

September-December X2 has Increased

Decade	X2	X2*	ΔX2
1950-1959		**73.7**	
1956-1959	73.2	**75.9**	-2.7
1960-1969	71.3	**73.3**	-2.0
1970-1979	73.3	**73.7**	-0.5
1980-1989	75.1	**72.5**	2.6
1990-1999	78.6	**75.9**	2.7
2000-2003	79.9	**74.2**	5.6
2000-2010	80.5		

Relative to what it would be with unimpaired flow

Cloern & Jassby 2012



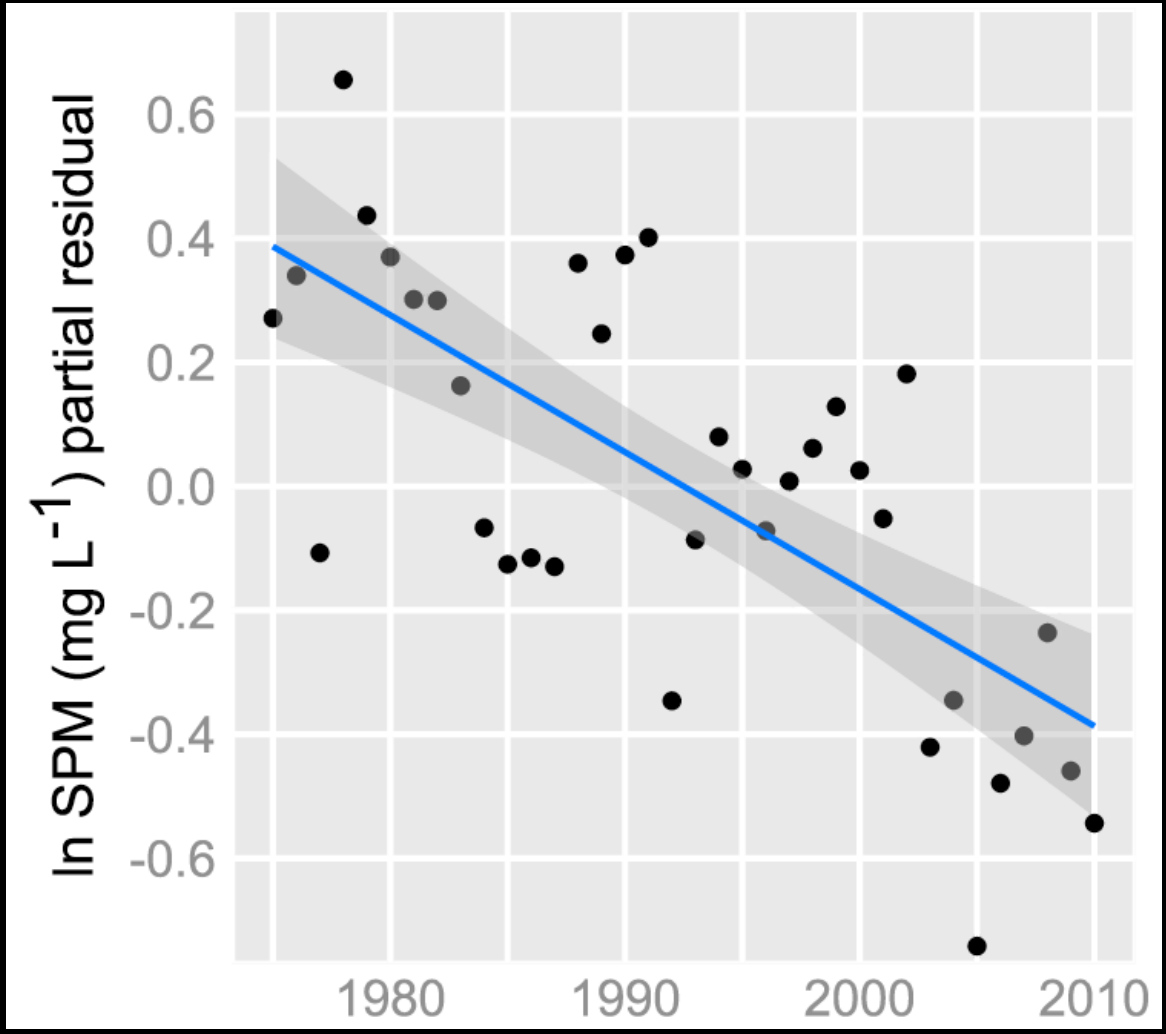
Abundances of estuarine organisms are correlated with X2

Salinity standards to protect native fishes

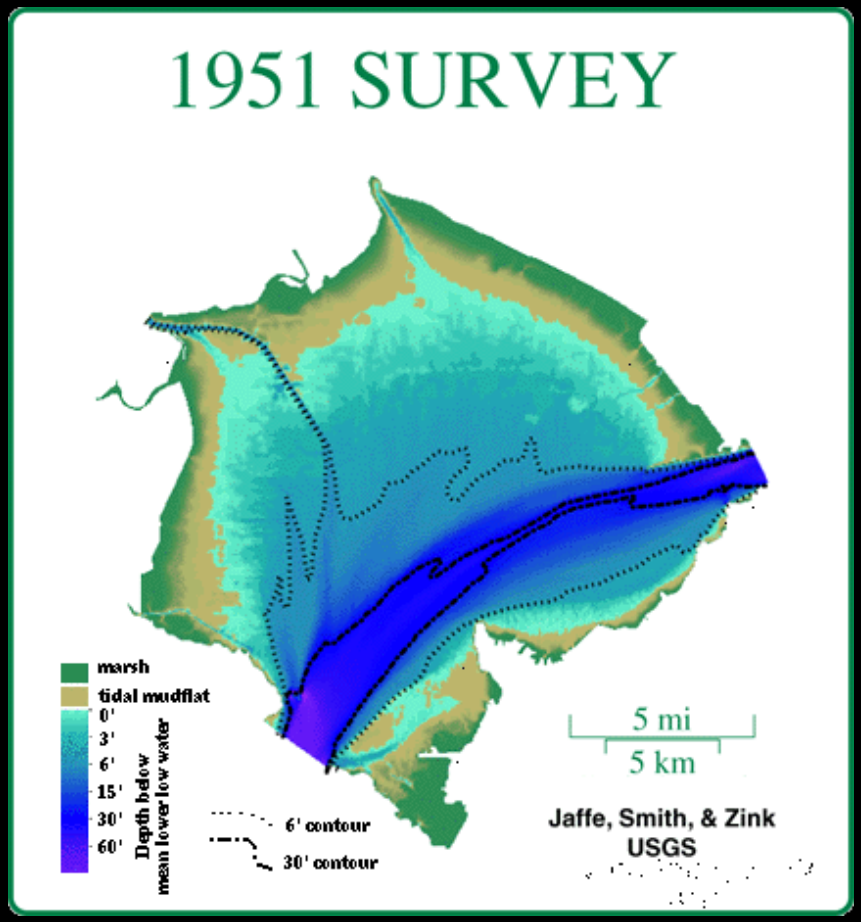
Jassby et al. 1995

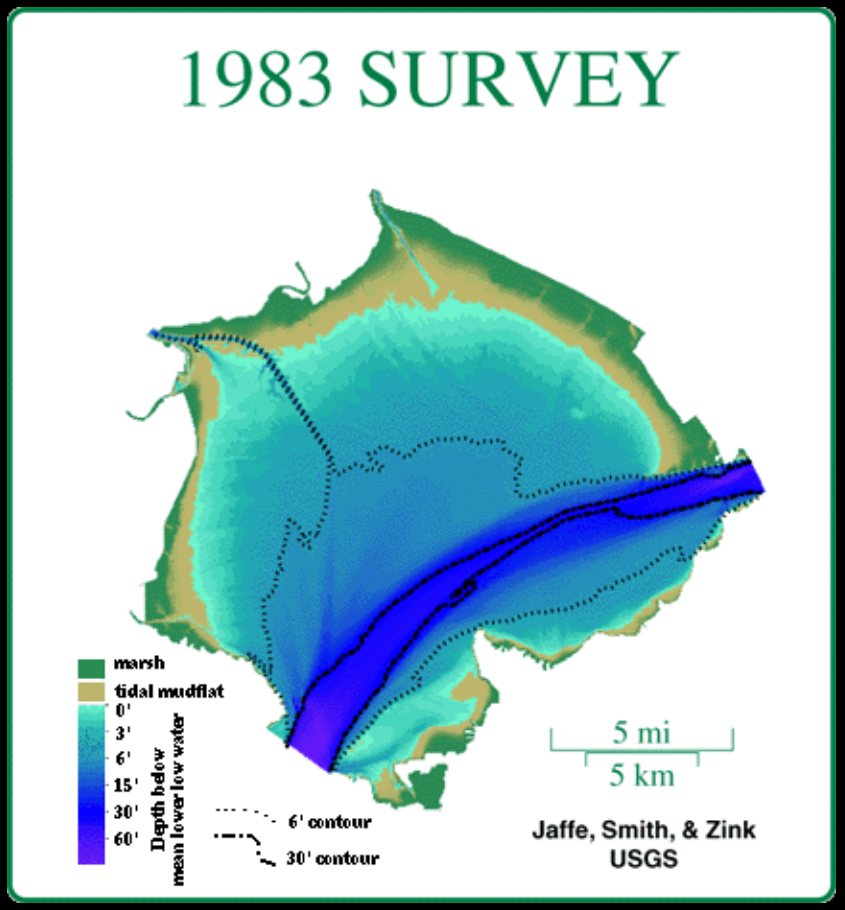
Effects on sediment supply
to the estuary

Sediment supply and turbidity have declined 50%



The Bay is losing sediments





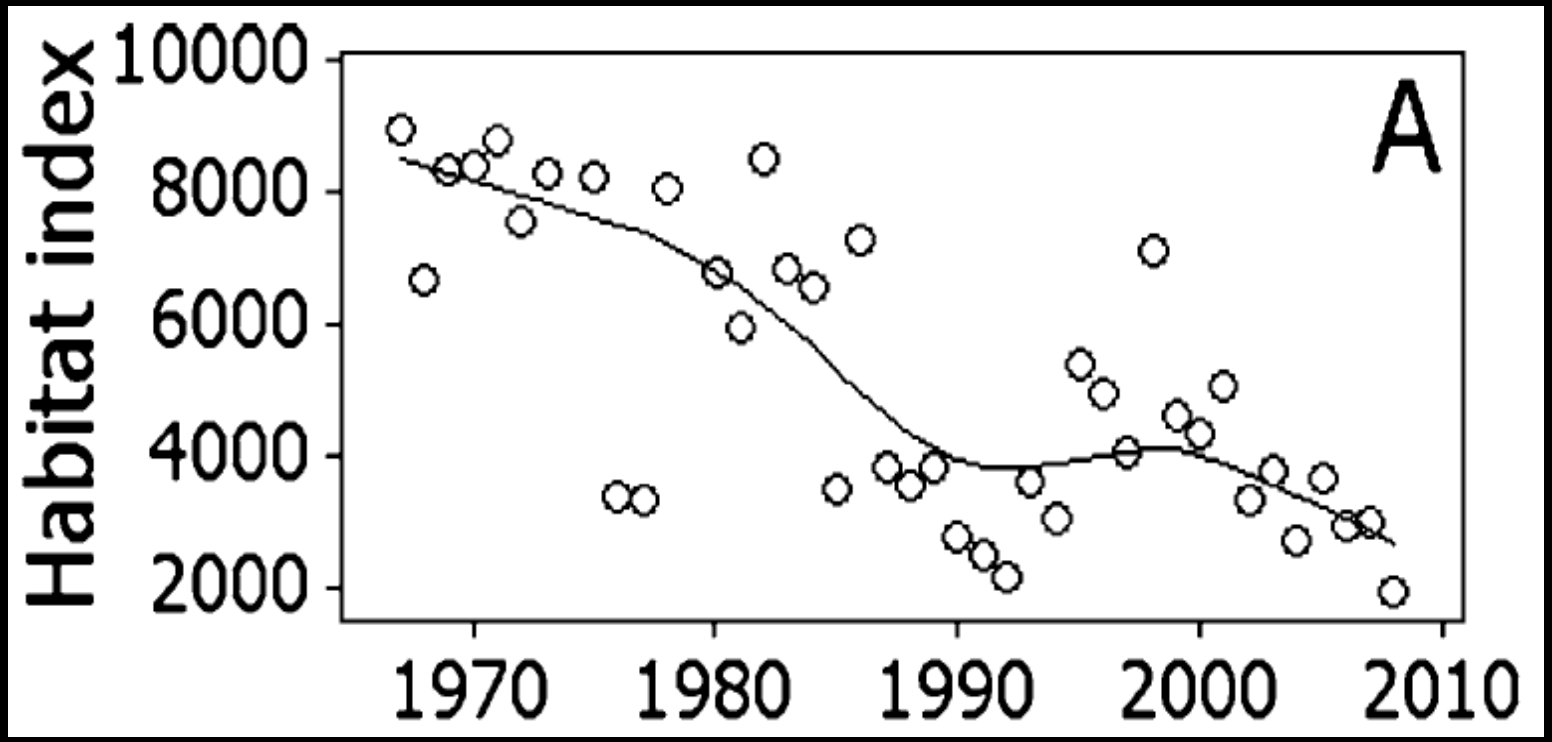
7 million m^3 eroded

3000 acres mudflat lost

Light penetrates deeper

Declining habitat quality for protected species

increasing salinity & decreasing turbidity

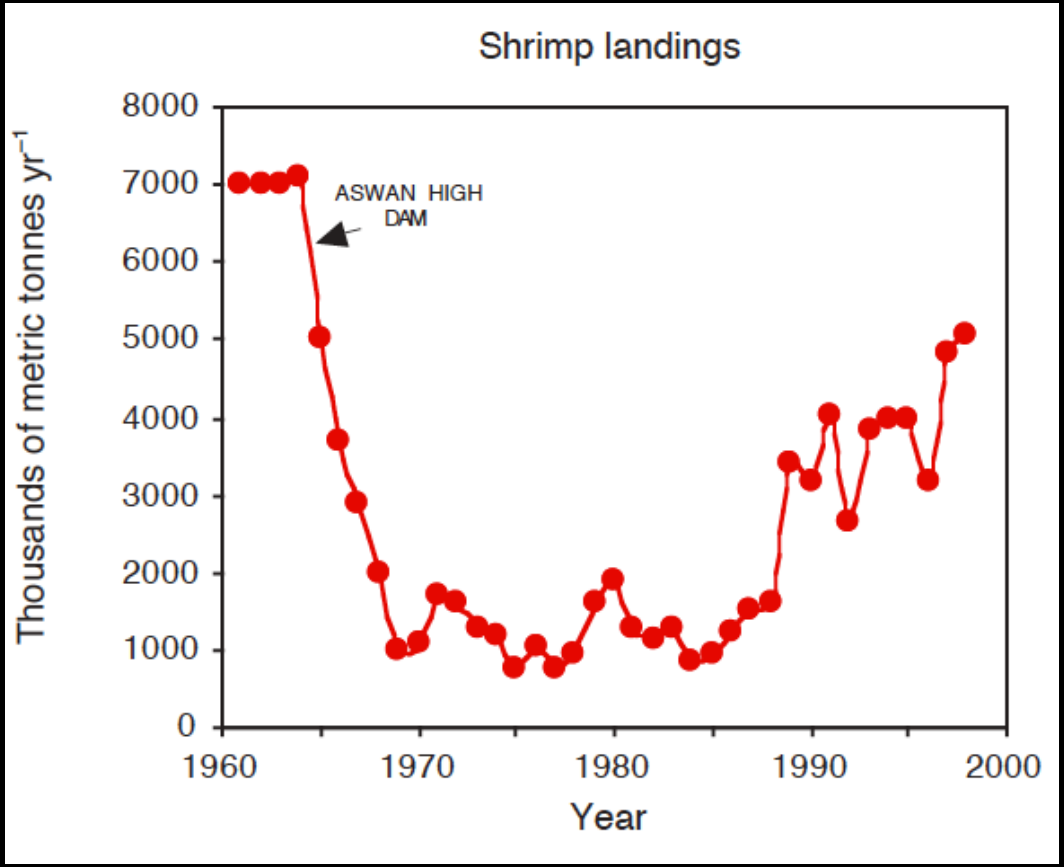


New flow autumn flow standards

Feyrer 2010

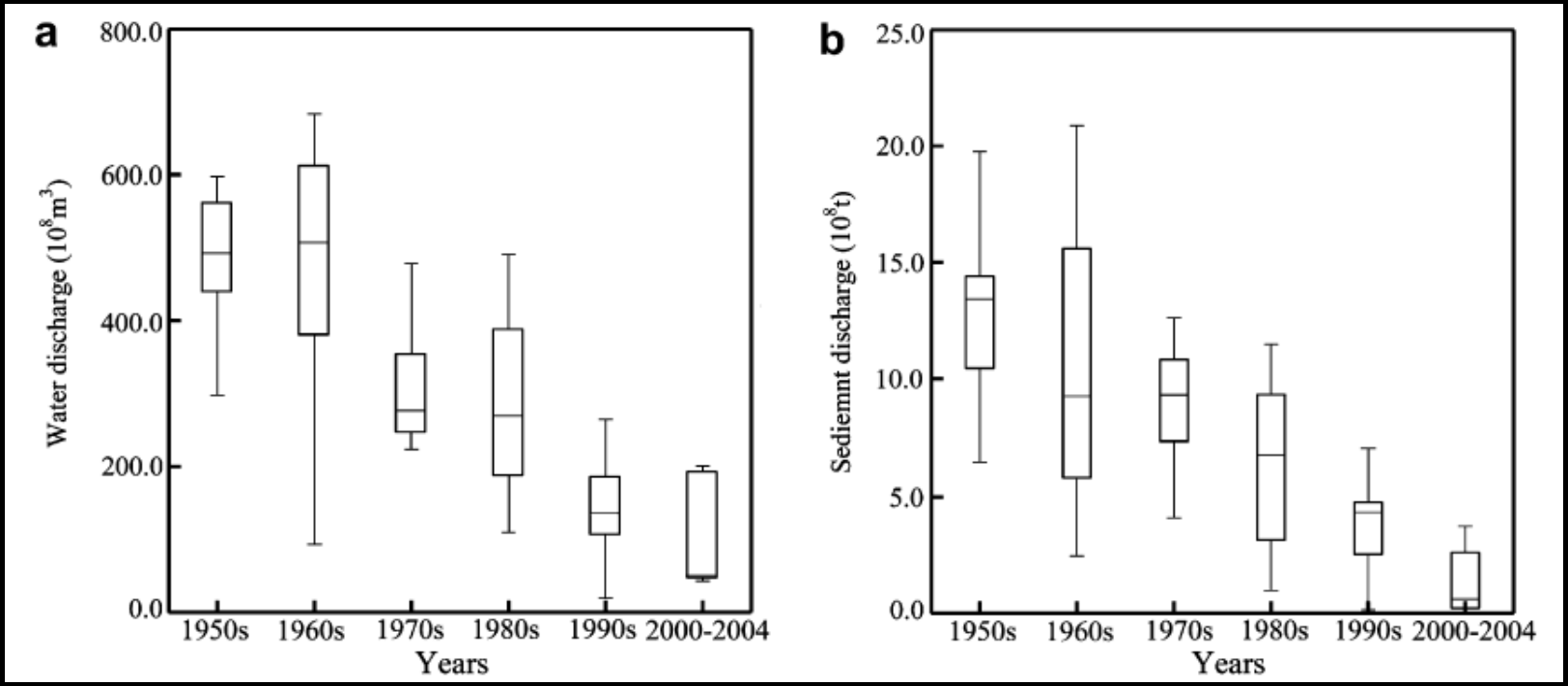
Many other examples

Abrupt decline of Egyptian coastal fisheries after damming the Nile



Nixon 2003

Water & sediment discharge to Huange Estuary



Primary production declined 30%

Number of fish species dropped from 146 to 73

Fish biomass dropped 46%

Fan & Huang 2008