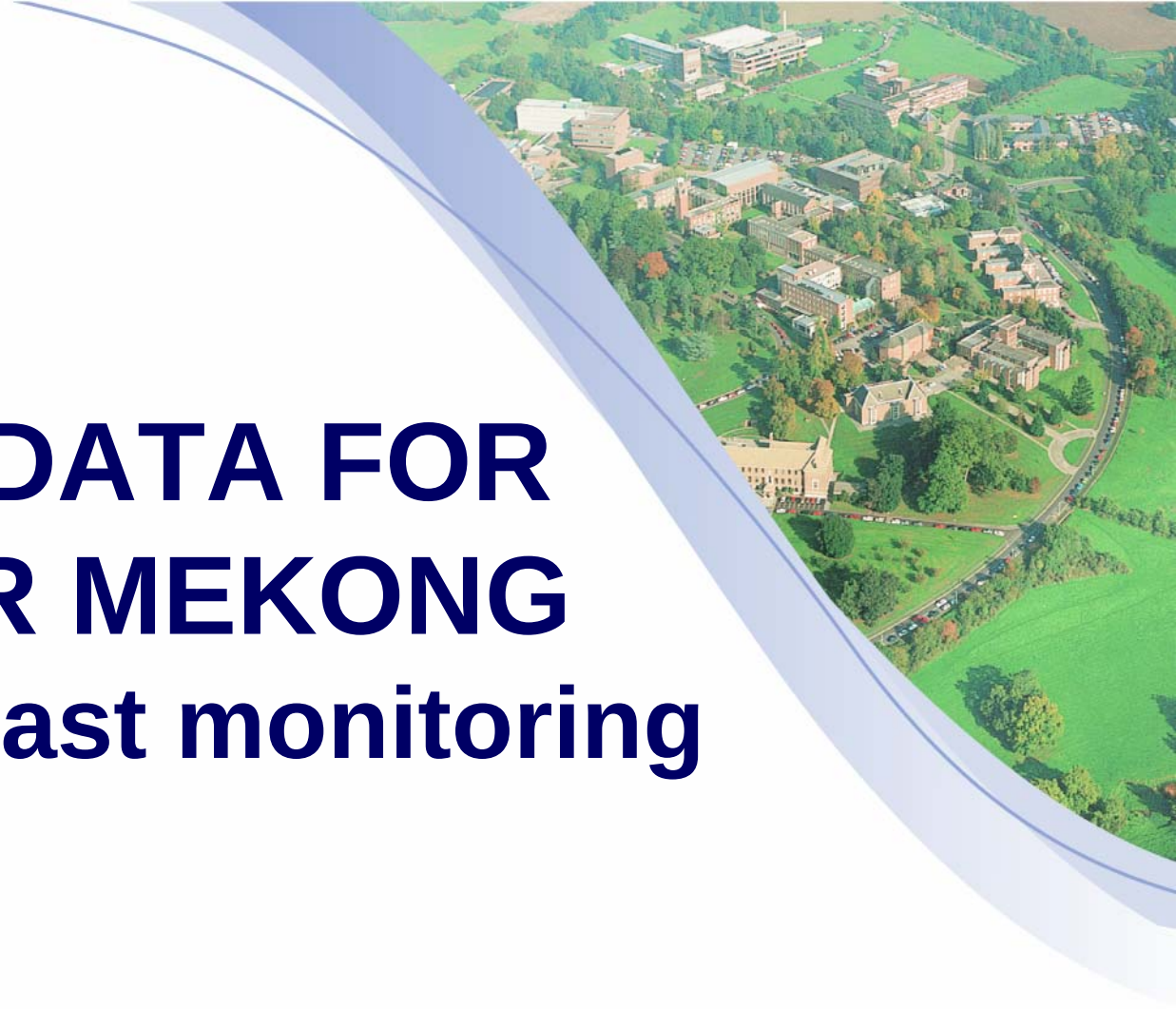


SEDIMENT DATA FOR THE LOWER MEKONG

A review of past monitoring activity

DES WALLING
DEPARTMENT OF GEOGRAPHY

Regional Workshop on Discharge and Sediment Monitoring and Geomorphological Tools for the Lower Mekong Basin, October 21-22, 2008.

LESSONS FROM THE PAST

- Limitations of past monitoring programmes
- Background information for planning future monitoring programmes
- Issues to be addressed when planning future monitoring programmes

Suspended Sediment Monitoring on the Mekong

- Measuring activities started in 1960
- Methods based on US practice
- Several sampling stations on main river
- Also Chinese measuring stations since mid 1960s
- Additional MRC Water Quality sampling for TSS since 1985

- Discontinuous records. Very few years with records for all stations
- Sampling frequency commonly low
- Raw concentration data only for main Mekong stations
- Some variations in practice between countries
- Chinese data unavailable since 1990
- Lack of continuous annual time series
- Water Quality data low frequency and possibly unreliable

- No reliable particle size data
- No detailed information on concentration profiles
- Limited information on sediment properties such as organic matter content
- No systematic measurement of bedload fluxes

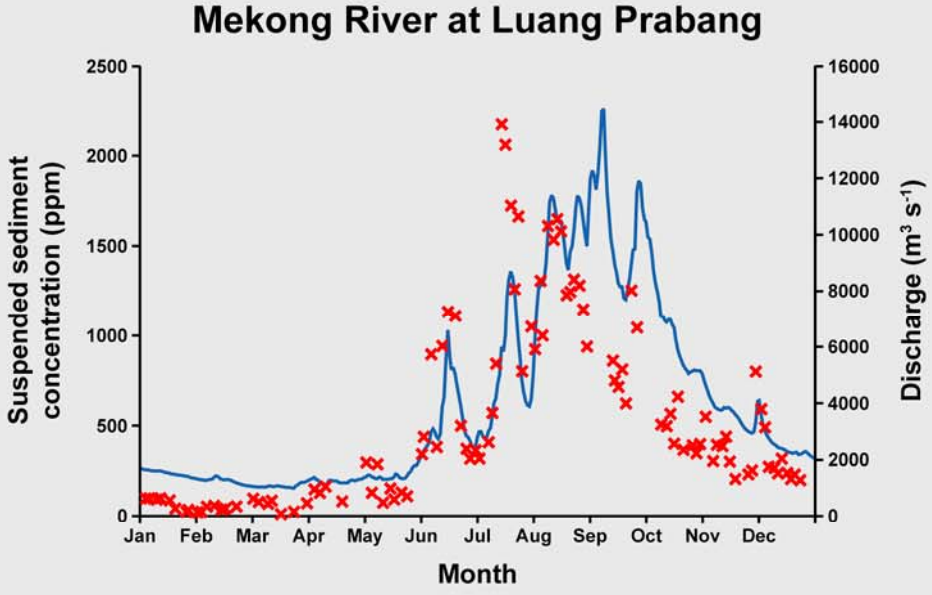
The Available Data

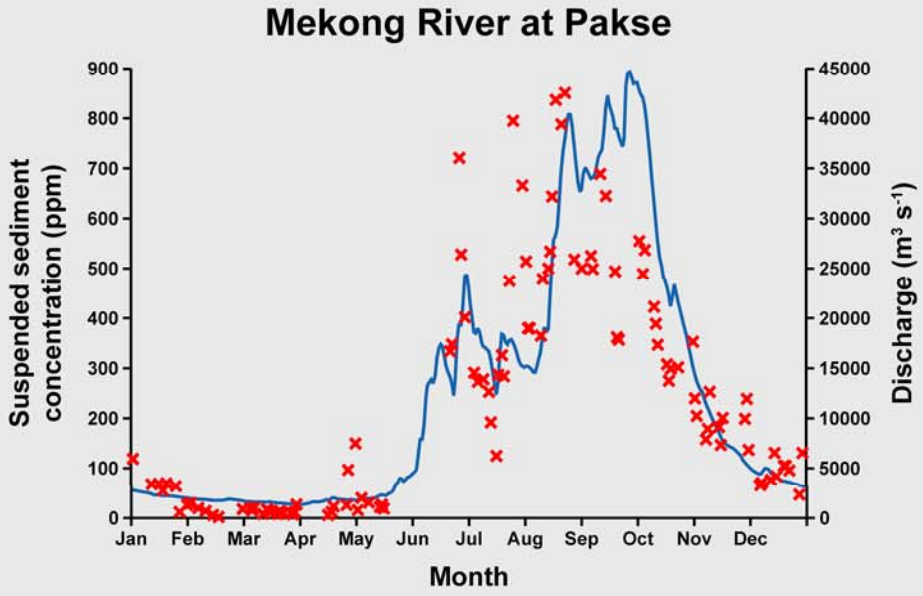

Measurement station
Mekong basin
National boundary
N
Mekong River
CHINA
Jinghong
MYANMAR
VIETNAM
HANOI
Chiang Saen
Luang Prabang
LAO PDR
South China Sea
Mekong River
VIENTIANE
Nong Khai
Mukdahan
THAILAND
Pakse
Andaman Sea
BANGKOK
Tonle Sap Lake
CAMBODIA
PHNOM PENH
HO CHI MINH CITY
0 100 200 300 400 500km

Year	Location				
	Chiang Saen	Luang Prabang	Nong Khai	Mukdahan	Pakse
1960	22	8		9	9
1961	20	105		60	109
1962	5			71	44
1963				32	
1964				42	
1965				38	
1966				35	
1967				42	
1968	38			45	
1969	73			66	
1970	83			73	
1971	71			58	
1972	65		58	72	
1973	33		89	74	
1974	33		87	71	
1975	9		33	36	
1976			27	16	
1977			46	26	
1978			47	26	
1979				27	
1980				25	
1981			21	22	
1982			16	19	
1983			18		
1984			16	20	
1985		2	4	1	
1986		22	18	18	
1987		43	15	4	
1988		41	14	6	
1989		44	20	11	
1990		37	22	14	
1991		18	14	19	
1992		37	23	21	
1993				19	
1994	48		24	22	
1995	45		15	18	
1996	32		20	19	
1997	39	12	25	11	11
1998	38	12	26	35	10
1999	40	7	29	43	12
2000	40	9	27	41	14
2001	38	11	30	42	13
2002	38	9	42	38	11
2003	36				

NUMBER OF DATA DAYS FOR INDIVIDUAL YEARS FOR THE SEDIMENT MEASURING STATIONS ON THE MEKONG RIVER

1961


Mekong River at Luang Prabang
Suspended sediment concentration (ppm)
Discharge (m3 s-1)
2500
2000
1500
1000
500
0
16000
14000
12000
10000
8000
6000
4000
2000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Mekong River at Pakse
Suspended sediment concentration (ppm)
Discharge (m3 s-1)
900
800
700
600
500
400
300
200
100
0
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Year	Location				
	Chiang Saen	Luang Prabang	Nong Khai	Mukdahan	Pakse
1960	22	8		9	9
1961	20	105		60	109
1962	5			71	44
1963				32	
1964				42	
1965				38	
1966				35	
1967				42	
1968	38			45	
1969	73			66	
1970	83			73	
1971	71			58	
1972	65		58	72	
1973	33		89	74	
1974	33		87	71	
1975	9		33	36	
1976			27	16	
1977			46	26	
1978			47	26	
1979				27	
1980				25	
1981			21	22	
1982			16	19	
1983			18		
1984			16	20	
1985		2	4	1	
1986		22	18	18	
1987		43	15	4	
1988		41	14	6	
1989		44	20	11	
1990		37	22	14	
1991		18	14	19	
1992		37	23	21	
1993				19	
1994	48		24	22	
1995	45		15	18	
1996	32		20	19	
1997	39	12	25	11	11
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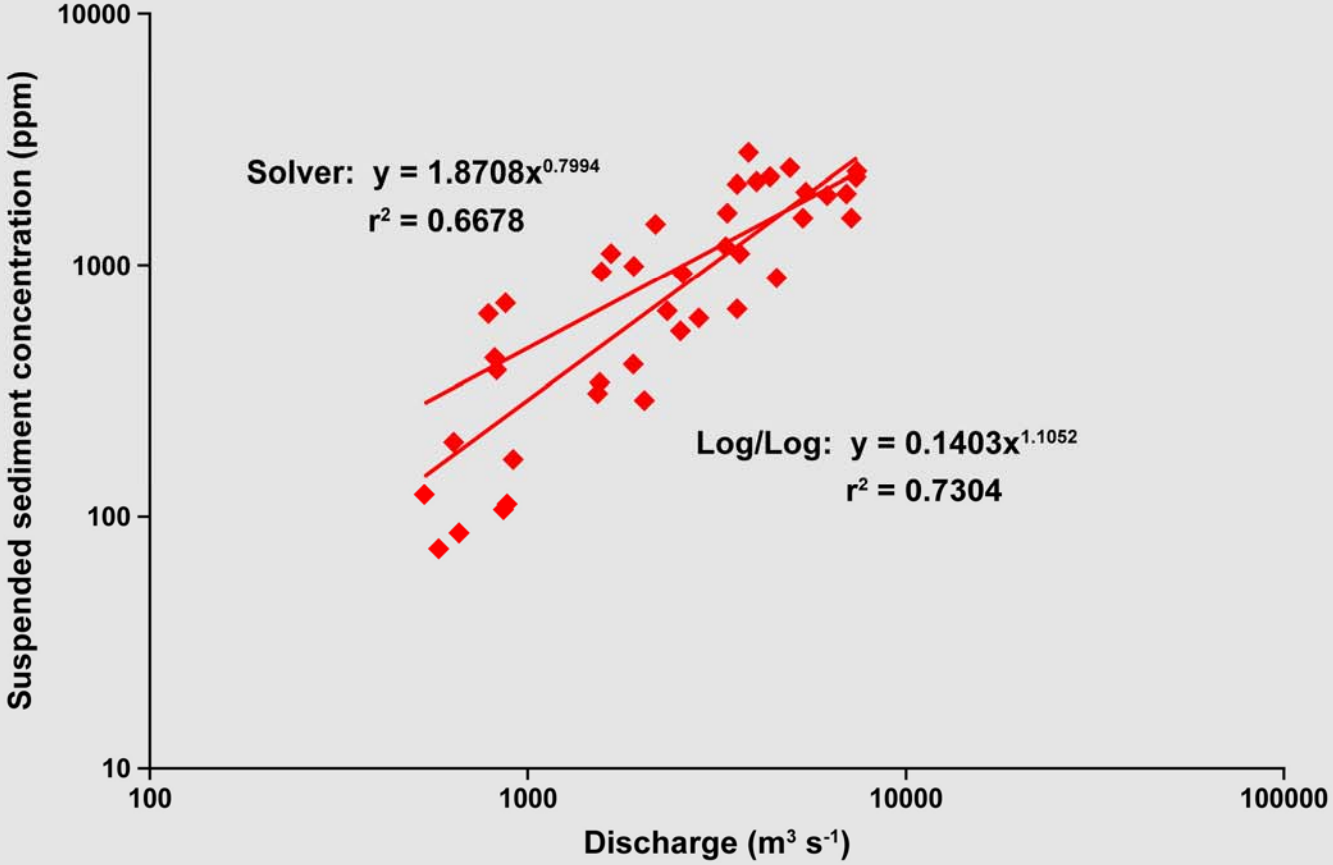
2003	36				

NUMBER OF DATA DAYS FOR INDIVIDUAL YEARS FOR THE SEDIMENT MEASURING STATIONS ON THE MEKONG RIVER

Focus on Annual Fluxes

Chiang Saen 1999



Minimum Data Requirements and Uncertainty of Resulting Load Estimates

Estimates of annual suspended sediment load (t x 10^6)		
7 day sampling frequency	14 day sampling frequency	28 day sampling frequency
159.2	153.5	156.8
159.7	151.0	164.6
163.4	153.0	169.7
159.4	155.2	172.0
157.9	156.3	173.3
157.9	159.6	178.8
157.9	161.8	182.9
Mean 159.4	164.9	185.3
Standard Deviation 1.96	168.2	186.5
	173.5	197.7
	163.4	184.4
	159.6	177.3
	156.2	165.6
	154.1	158.6
	Mean 159.3	153.9
	Standard Deviation 6.45	145.6
		143.7
		143.6
		140.7
		141.3
		142.5
		145.4
		149.4
		147.8
		141.1
		141.5
		147.2
		151.4
		Mean 160.3
		Standard Deviation 17.5

PAKSE 1961

Best estimate of annual load

= 159.0 million tonnes

ESTIMATES OF UNCERTAINTY AT THE 95% LEVEL OF CONFIDENCE FOR ANNUAL LOAD ESTIMATES DERIVED USING SAMPLES COLLECTED AT DIFFERENT SAMPLING FREQUENCIES

Station and Year	Level of uncertainty in load estimates at the 95% level of confidence		
	7 day sampling	14 day sampling	28 day sampling
Pakse 1961	± 2.5%	± 8.1%	± 22.0%
Mukdahan 1972	± 2.7%	± 5.5%	± 25.5%
Mukdahan 1970	± 0.5%	± 4.7%	± 11.1%
Nong Kai 1977	± 9.4%	± 13.8%	± 36.8%
Nong Kai 1974	± 1.7%	± 4.8%	± 19.8%
Luang Prabang 1961	± 8.7%	± 13.7%	± 23.7%
Chiang Saen 1999	± 2.5%	± 6.3%	± 18.9%
Chiang Saen 2001	± 2.9%	± 4.6%	± 16.9%
Chiang Saen 2003	± 2.4%	± 7.2%	± 20.9%

Year	Location				
	Chiang Saen	Luang Prabang	Nong Khai	Mukdahan	Pakse
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1969	73			66	
1970	83			73	
1971	71			58	
1972	65		58	72	
1973	33		89	74	
1974	33		87	71	
1975	9		33	36	
1976			27	16	
1977			46	26	
1978			47	26	
1979				27	
1980				25	
1981			21	22	
1982			16	19	
1983			18		
1984			16	20	
1985		2	4	1	
1986		22	18	18	
1987		43	15	4	
1988		41	14	6	
1989		44	20	11	
1990		37	22	14	
1991		18	14	19	
1992		37	23	21	
1993				19	
1994	48		24	22	
1995	45		15	18	
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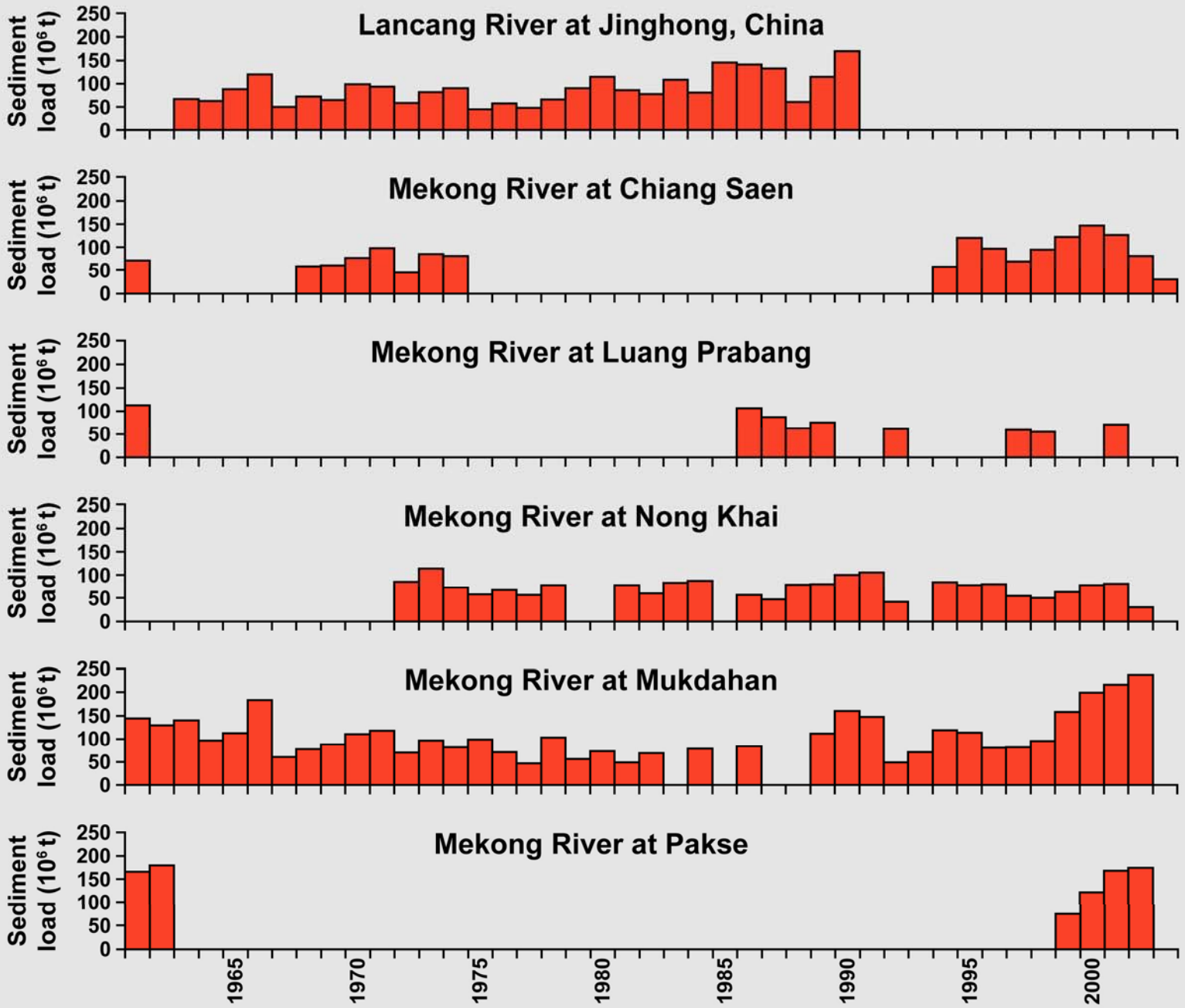
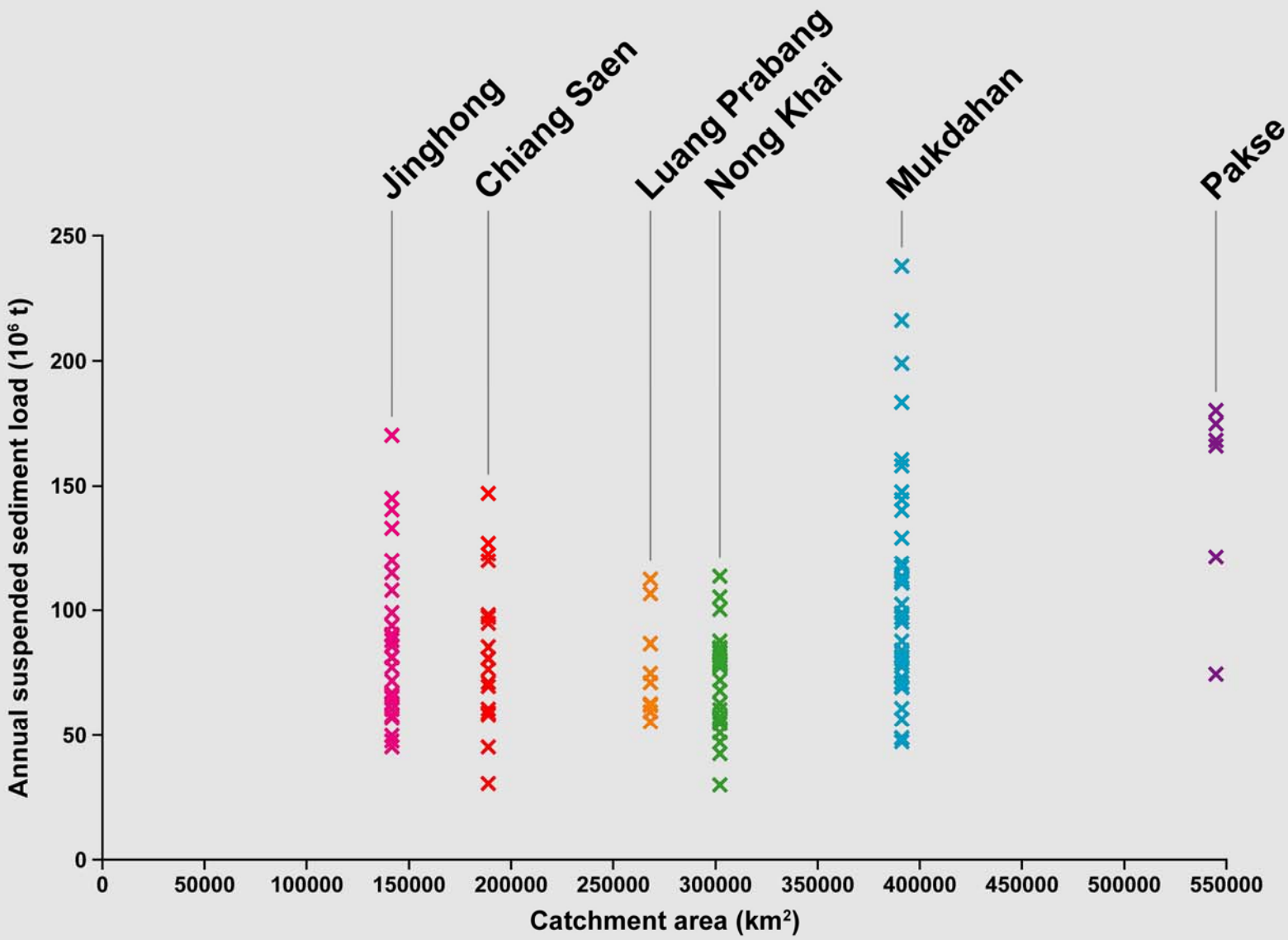
2001	38	11	30	42	13
2002	38	9	42	38	11
2003	36				

NUMBER OF DATA DAYS FOR INDIVIDUAL YEARS FOR THE SEDIMENT MEASURING STATIONS ON THE MEKONG RIVER

Year	Location				
	Chiang Saen	Luang Prabang	Nong Khai	Mukdahan	Pakse
1960	incomplete Q				
1961	71.3	112.4		144.5	165.79
1962				129.1	179.97
1963				140.2	
1964				*96.9*	
1965				112.1	
1966				183.2	
1967				*60.8*	
1968	59.1			77.6	
1969	60.6			87.6	
1970	76.6			110.8	
1971	98.2			117.3	
1972	45.2		85.01	69.6	
1973	85.4		113.6	97.0	
1974	80.8		72.2	81.5	
1975			57.5	98.8	
1976			67.9	71.3	
1977			56.5	47.3	
1978			77.5	102.4	
1979				56.5	
1980				73.2	
1981			78.3	*48.9*	
1982			60.3	69.2	
1983			83.4		
1984			87.6	79.0	
1985					
1986		106.6	*56.9*	84.0	
1987		86.7	*47.1*		
1988		62.7	79.0		
1989		74.9	80.5	111.2	
1990			100.3	160.3	
1991			105.3	147.6	
1992		62.0	42.5	48.7	
1993				71.1	
1994	58.3		84.4	118.9	
1995	*119.9*		*78.5*	113.4	
1996	*97.2*		79.9	80.6	
1997	69.7	59.5	54.7	81.7	
1998	94.8	55.4	51.0	95.2	
1999	122.6		62.8	157.8	74.6
2000	147.0		*78.4*	199.1	121.4
2001	127.0	71.2	81.7	216.3	168.0
2002	81.1		*29.9*	237.8	174.6
2003	30.5				

The values in cells coloured yellow and orange are judged to be reliable, whereas those printed in red italics involve greater uncertainty, due to the lack of a well-defined rating relationship


Lancang River at Jinghong, China
Mekong River at Chiang Saen
Mekong River at Luang Prabang
Mekong River at Nong Khai
Mekong River at Mukdahan
Mekong River at Pakse
Sediment load (10^6 t)
0
50
100
150
200
250
1965
1970
1975
1980
1985
1990
1995
2000


Jinghong
Chiang Saen
Luang Prabang
Nong Khai
Mukdahan
Pakse
Annual suspended sediment load (10⁶ t)
0
50
100
150
200
250
0
50000
100000
150000
200000
250000
300000
350000
400000
450000
500000
550000
Catchment area (km²)

Some Warning Messages

- Sampling Frequency
- Use of Water Quality Data

Sampling Frequency

- Data requirements - What data are needed?
- Required accuracy
- Reconstruction of actual concentration or flux time series OR
- Use of rating curves

ESTIMATES OF UNCERTAINTY AT THE 95% LEVEL OF CONFIDENCE FOR ANNUAL LOAD ESTIMATES DERIVED USING SAMPLES COLLECTED AT DIFFERENT SAMPLING FREQUENCIES

Station and Year	Level of uncertainty in load estimates at the 95% level of confidence		
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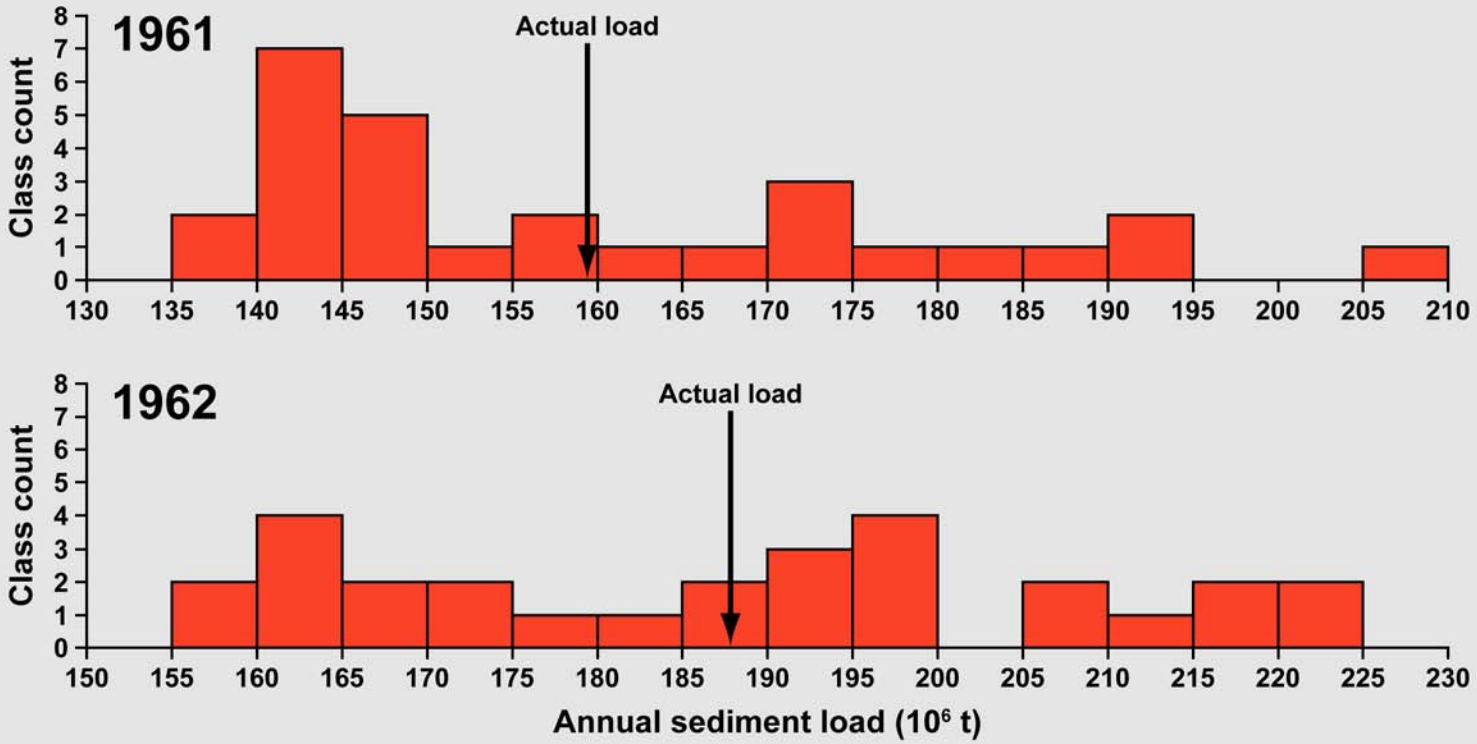
Nong Kai 1974	± 1.7%	± 4.8%	± 19.8%
Luang Prabang 1961	± 8.7%	± 13.7%	± 23.7%
Chiang Saen 1999	± 2.5%	± 6.3%	± 18.9%
Chiang Saen 2001	± 2.9%	± 4.6%	± 16.9%
Chiang Saen 2003	± 2.4%	± 7.2%	± 20.9%

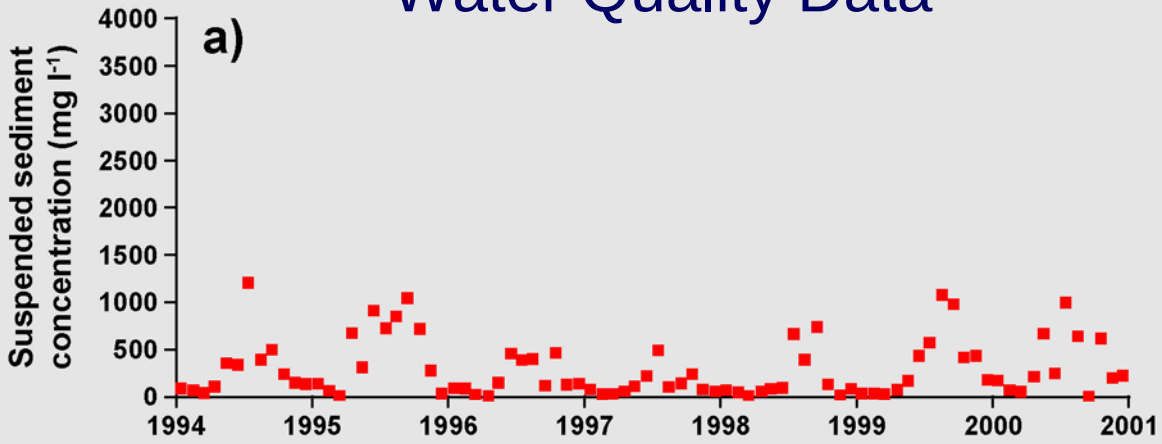
Use of Water Quality Data

Mekong River at Pakse

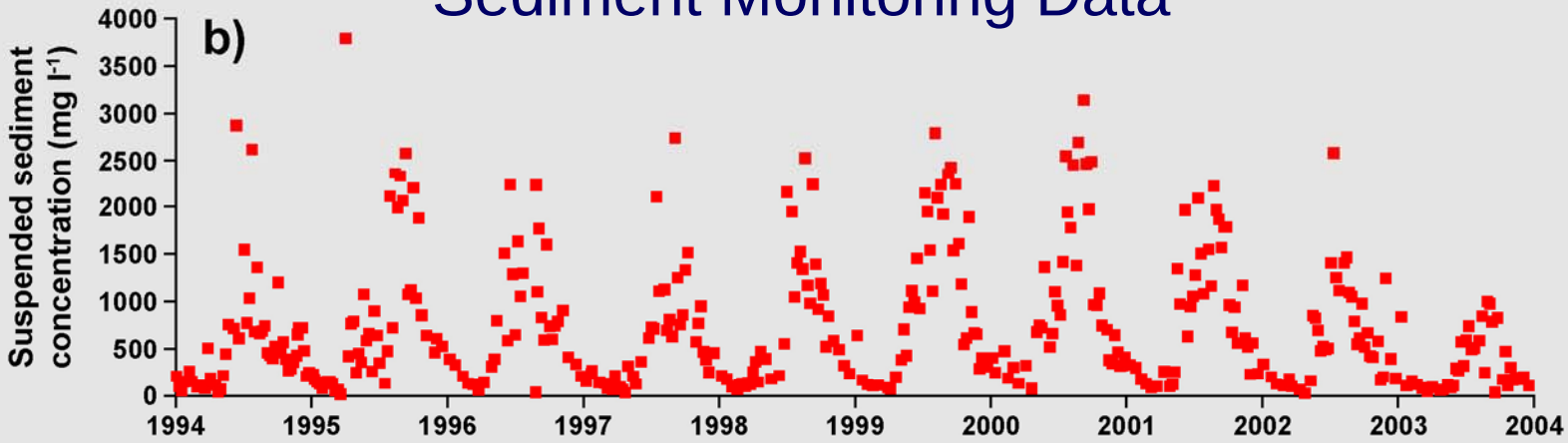


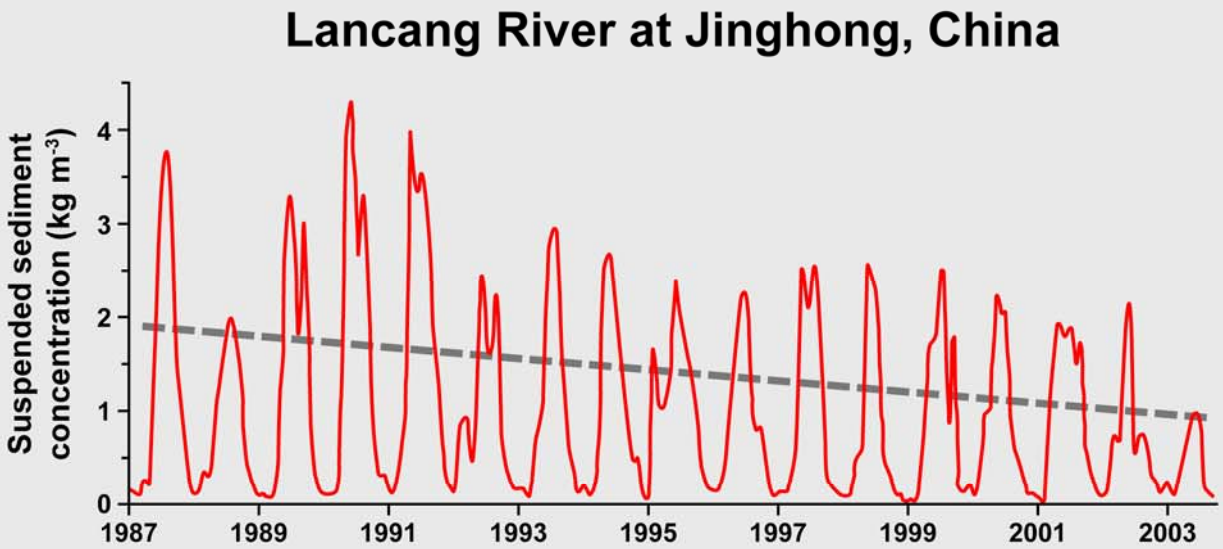
Mekong at Chiang Saen

Water Quality Data

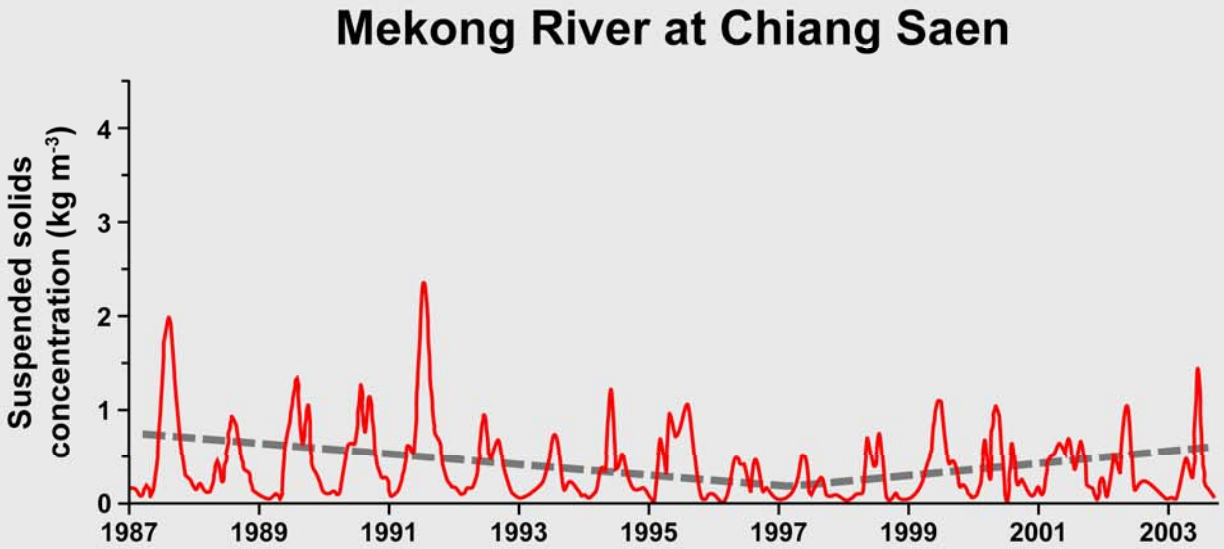


Sediment Monitoring Data





Data for Lancang River based on Fu et al. (2006)

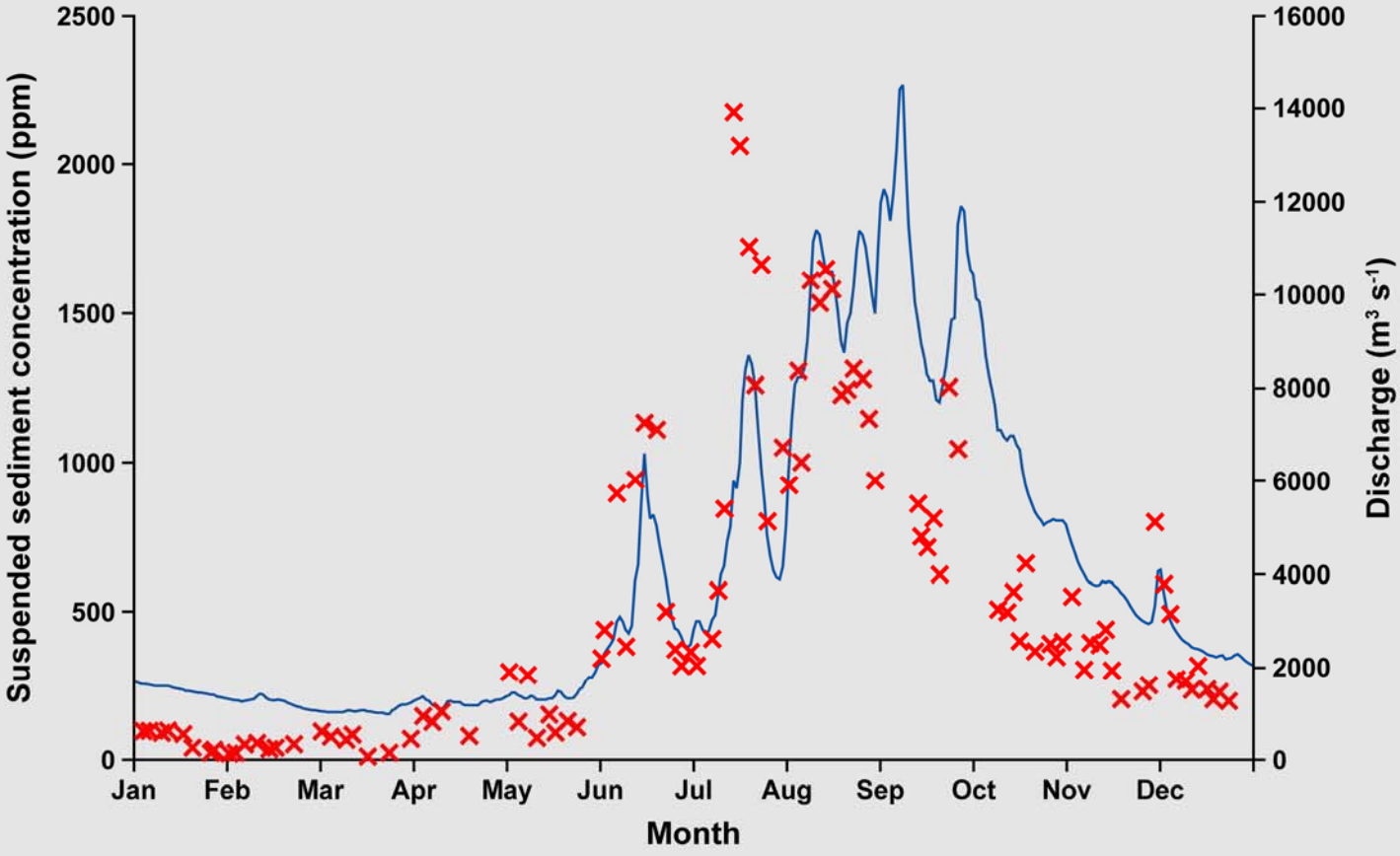


Thank You

Site and Year	Annual load 'best estimate'	Annual load log/log	Annual load Solver
Chiang Saen 1999	120.8	125.4	122.5
Luang Prabang 1961	102.7	109.3	113.1
Nong Khai 1977	49.3	53.9	52.8
Mukdahan 1998	98.4	100.3	97.0
Pakse 1961	160.8	182.0	143.5

The predicted annual loads that are closest to the 'best estimate' of the annual load are identified by the yellow (shaded) cells

Luang Prabang 1961



Estimates of annual suspended sediment load (t x 10^6)		
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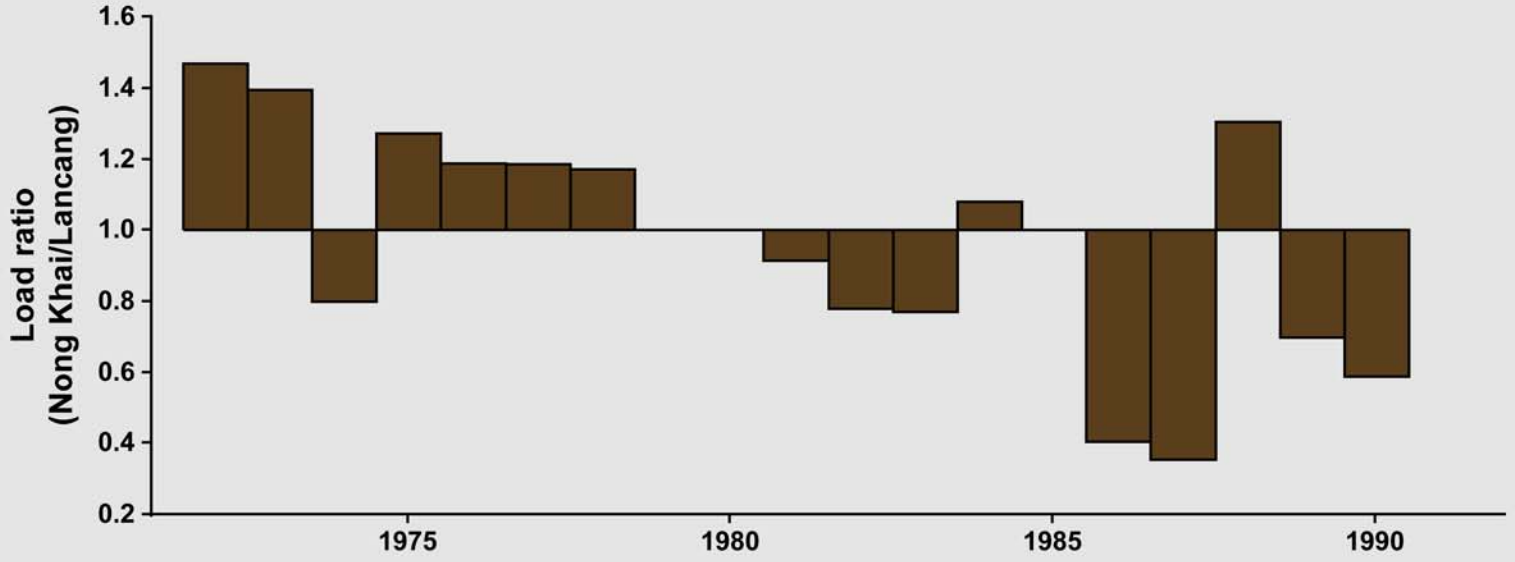
		143.7
		143.6
		140.7
		141.3
		142.5
		145.4
		149.4
		147.8
		141.1
		141.5
		147.2
		151.4
		Mean 160.3
		Standard Deviation 17.5

PAKSE 1961

Best estimate of annual load

= 159.0 million tonnes


Load ratio
(Nong Khai/Lancang)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
1975
1980
1985
1990

Luang Prabang 1961