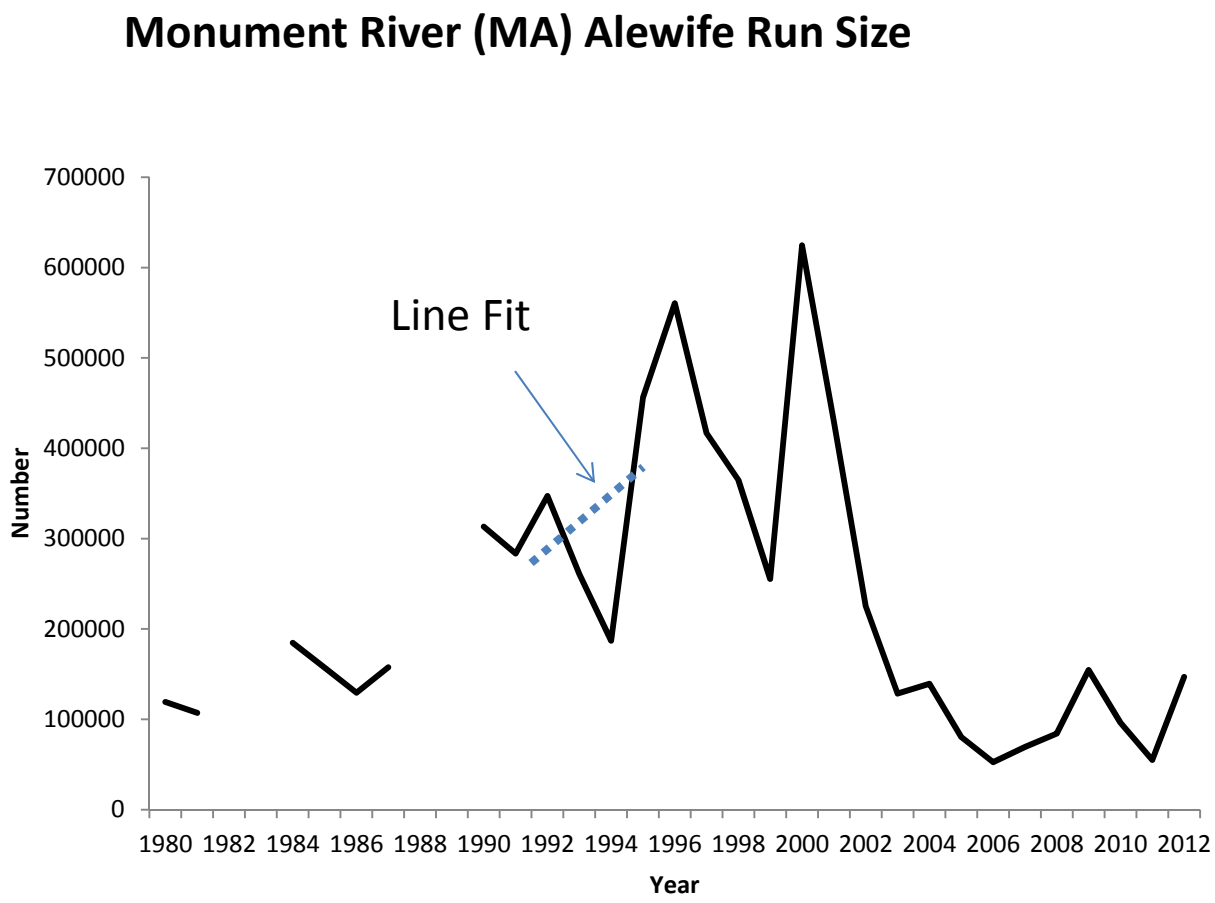
Method 1

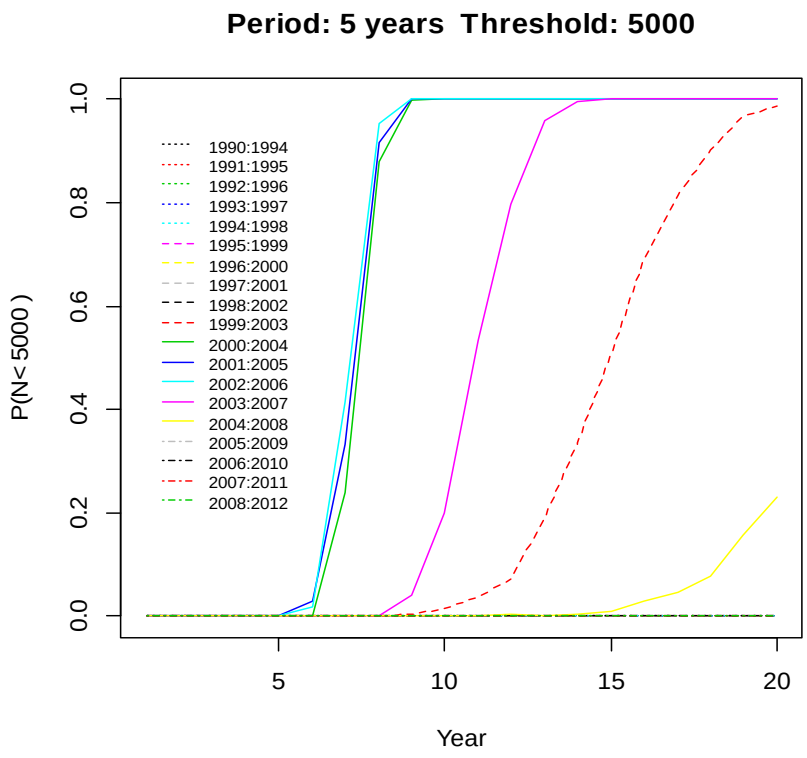
1. Fit Equation (*ln(Nt)=ln(N0)+ln(R)*t*) to data for X years



2. Based on line fit, project population (applying error to the estimate) forward *d* years and repeat *J* times

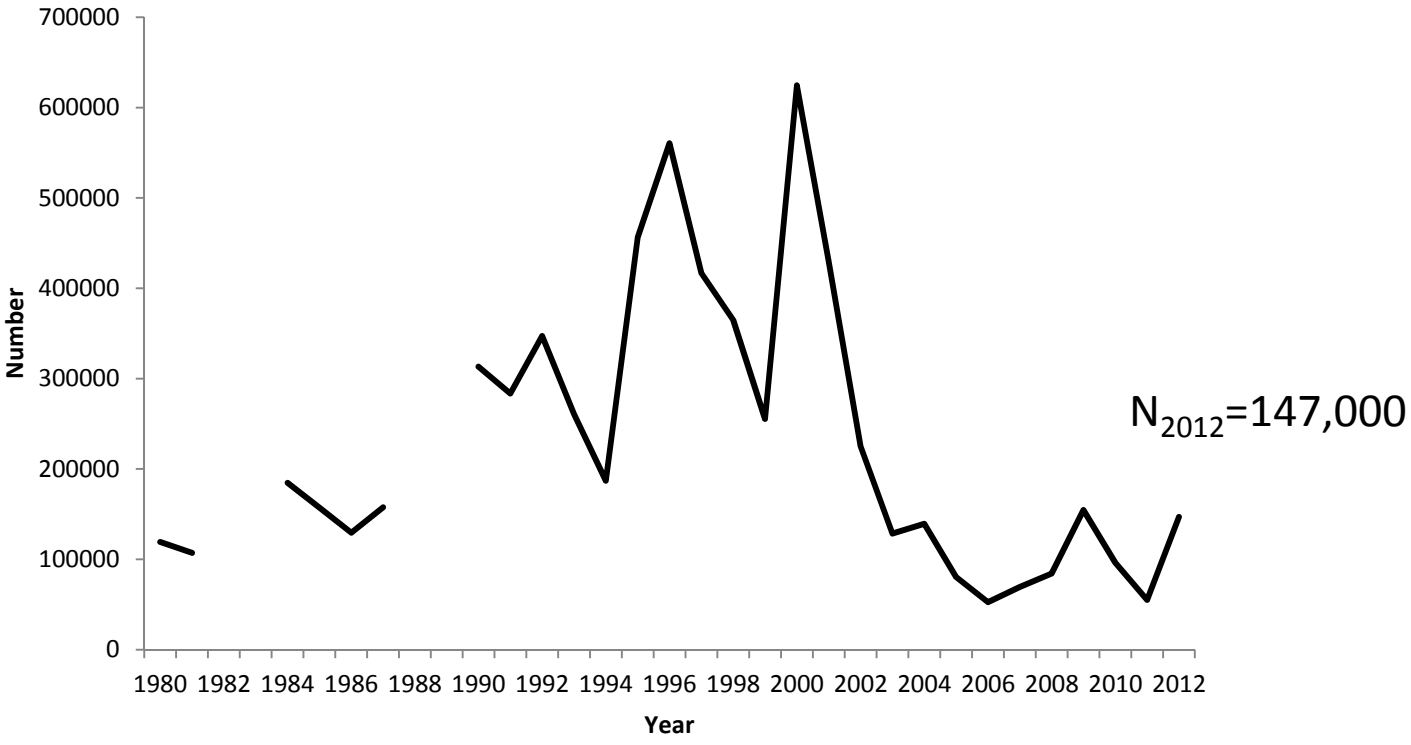
3. Calculate probability of going below threshold *th* over *d* years

4. Move window one year ahead, refit equation to new data and repeat 2-3

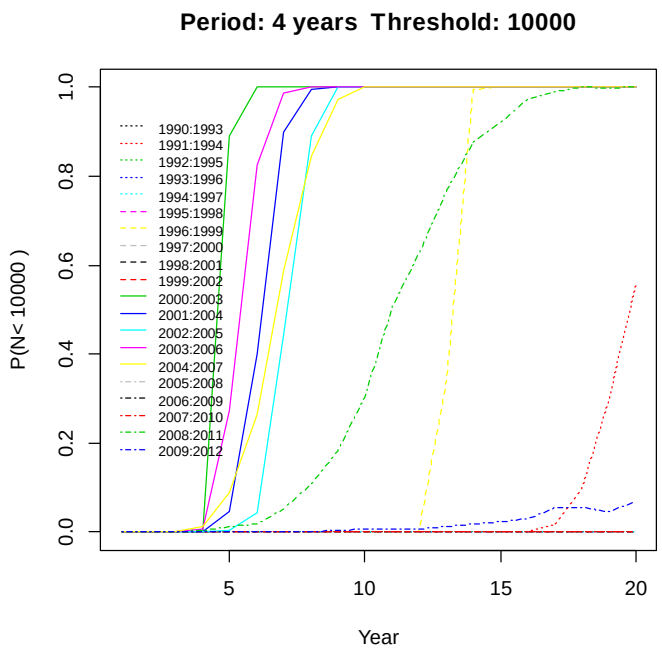


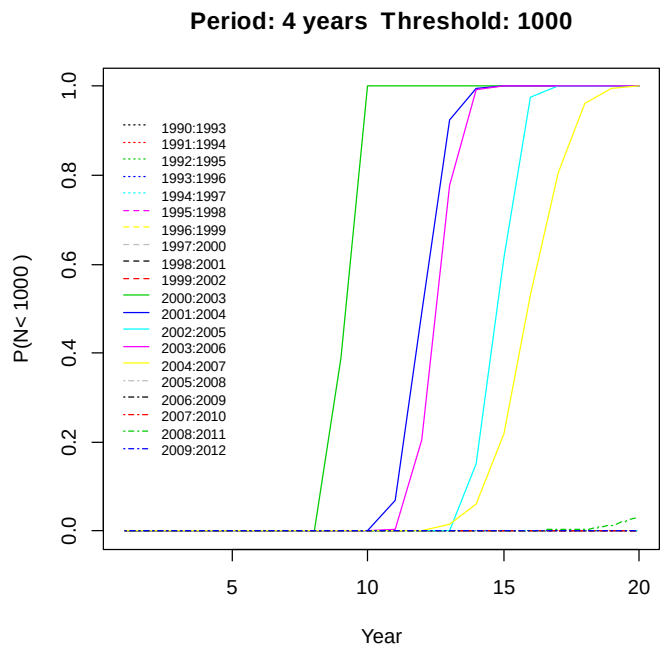
Alewife Examples

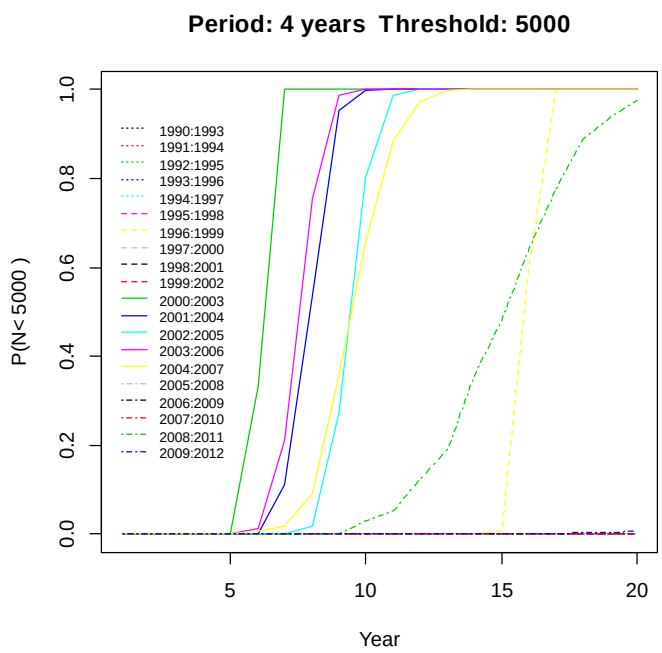
Monument River (MA) Alewife Run Size

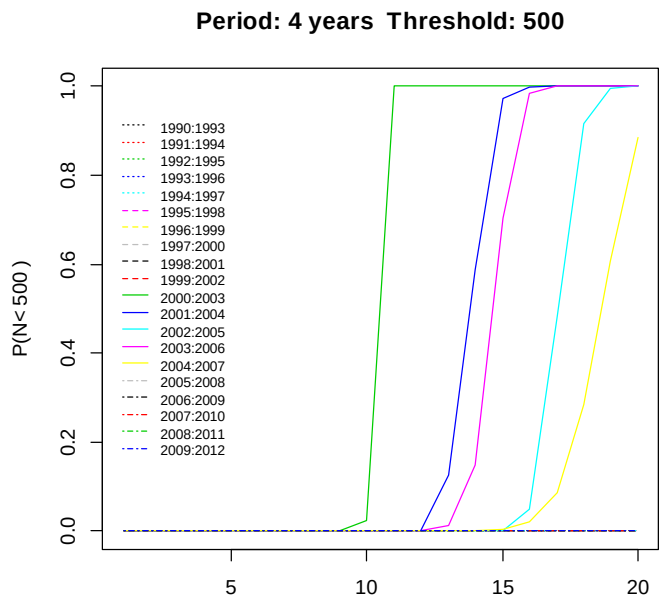


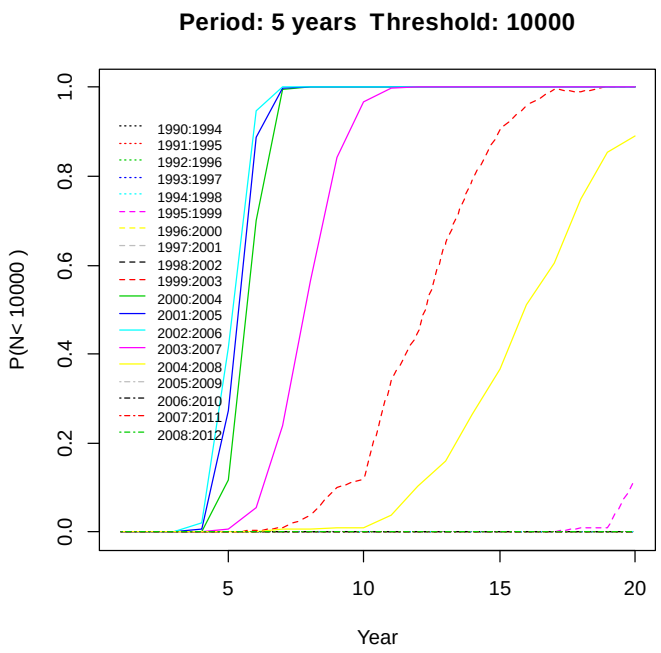
Monument River Results

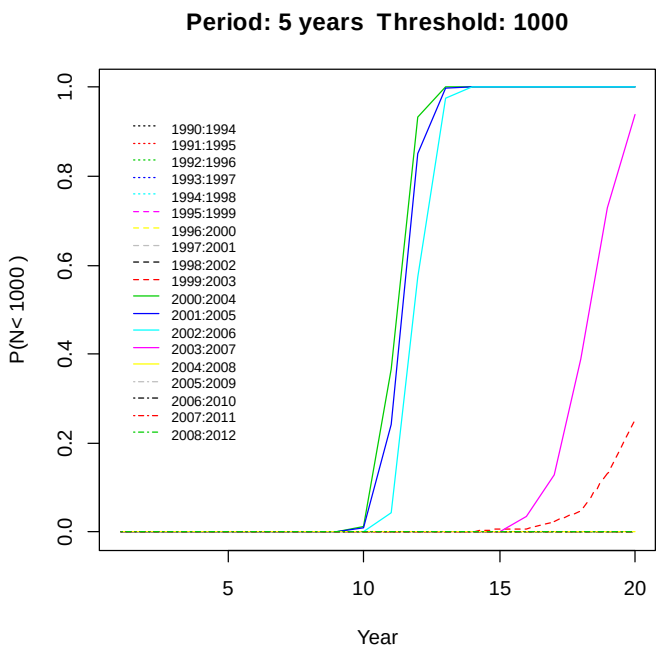


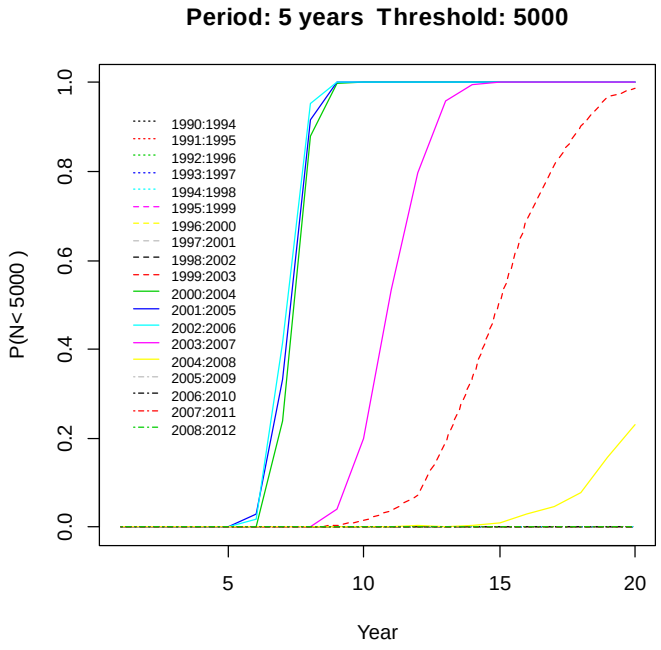


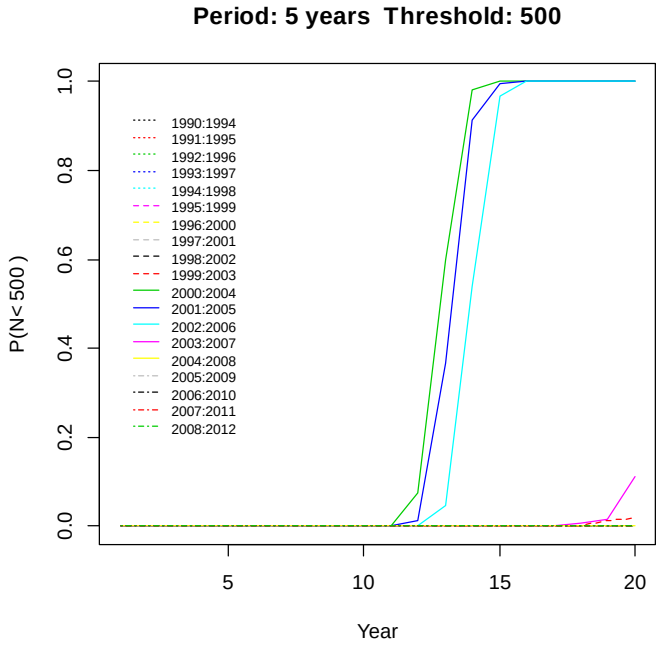


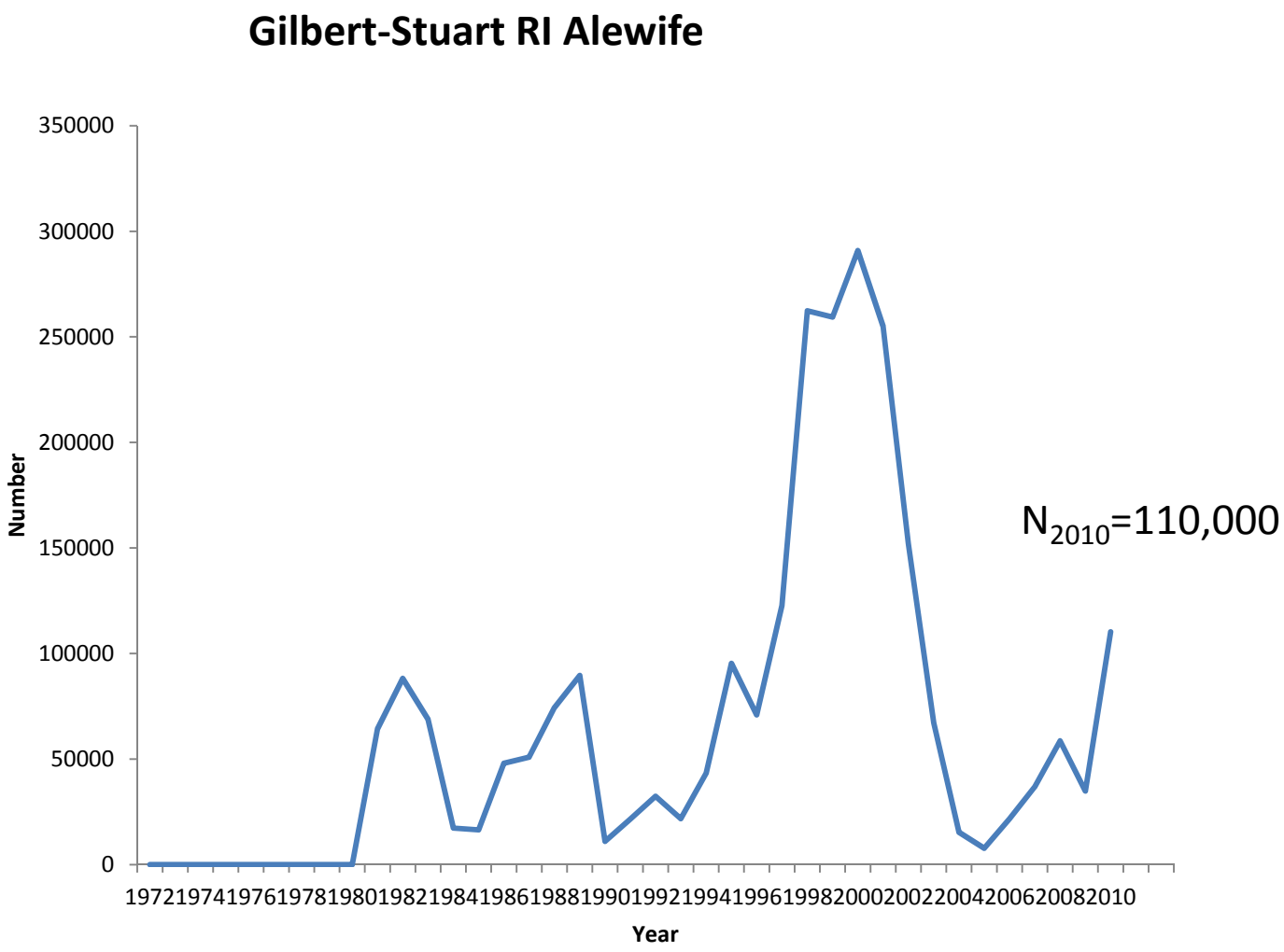


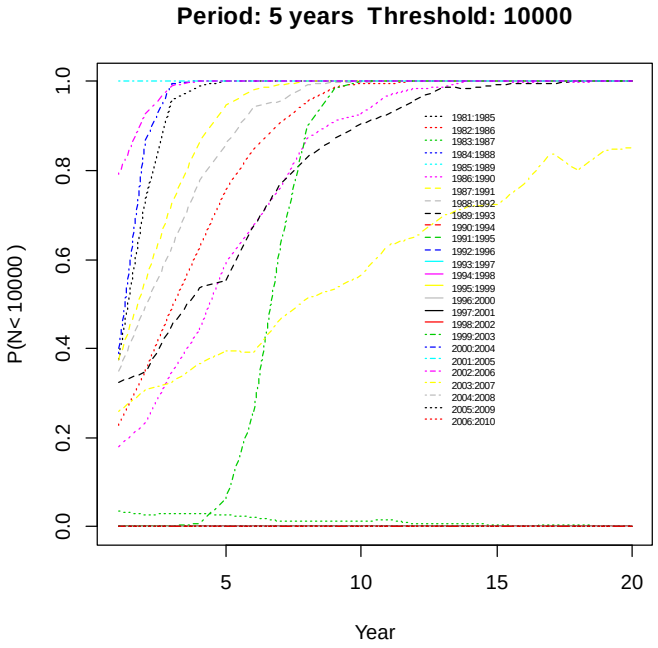

Period: 5 years Threshold: 10000
P(N< 10000)
Year
1990:1994
1991:1995
1992:1996
1993:1997
1994:1998
1995:1999
1996:2000
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010
2007:2011
2008:2012

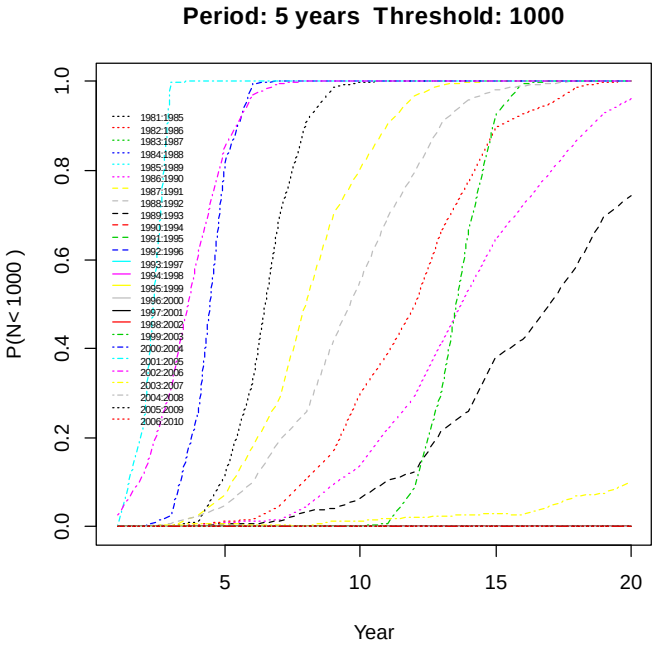

Period: 5 years Threshold: 1000
P(N< 1000)
Year
1990:1994
1991:1995
1992:1996
1993:1997
1994:1998
1995:1999
1996:2000
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010
2007:2011
2008:2012

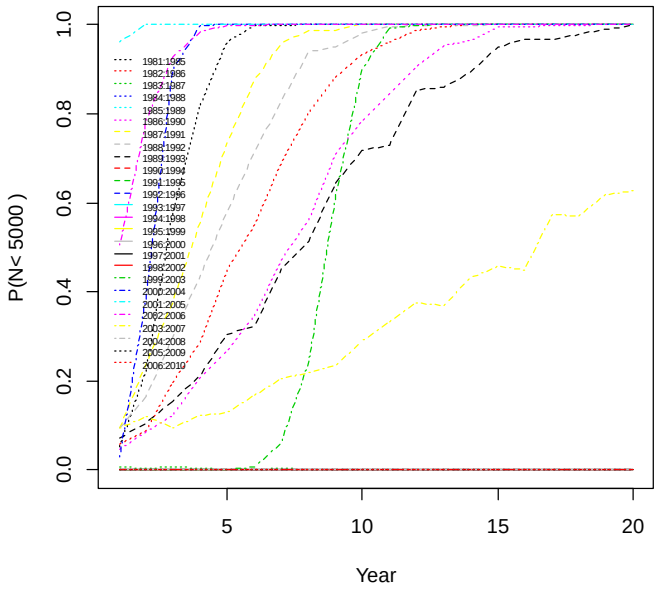

Period: 5 years Threshold: 5000
P(N< 5000)
Year
1990:1994
1991:1995
1992:1996
1993:1997
1994:1998
1995:1999
1996:2000
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010
2007:2011
2008:2012


Period: 5 years Threshold: 500
P(N< 500)
Year
1990:1994
1991:1995
1992:1996
1993:1997
1994:1998
1995:1999
1996:2000
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010
2007:2011
2008:2012


Gilbert-Stuart RI Alewife
350000
300000
250000
200000
150000
100000
50000
0
Number
1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010
Year
N2010=110,000


Period: 5 years Threshold: 10000
P(N< 10000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
1987:1991
1988:1992
1989:1993
1990:1994
1991:1995
1992:1996
1993:1997
1994:1998
1995:1999
1996:2000
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010


Period: 5 years Threshold: 1000
P(N< 1000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
1987:1991
1988:1992
1989:1993
1990:1994
1991:1995
1992:1996
1993:1997
1994:1998
1995:1999
1996:2000
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010


Period: 5 years Threshold: 5000
P(N< 5000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
1987:1991
1988:1992
1989:1993
1990:1994
1991:1995
1992:1996
1993:1997
1994:1998
1995:1999
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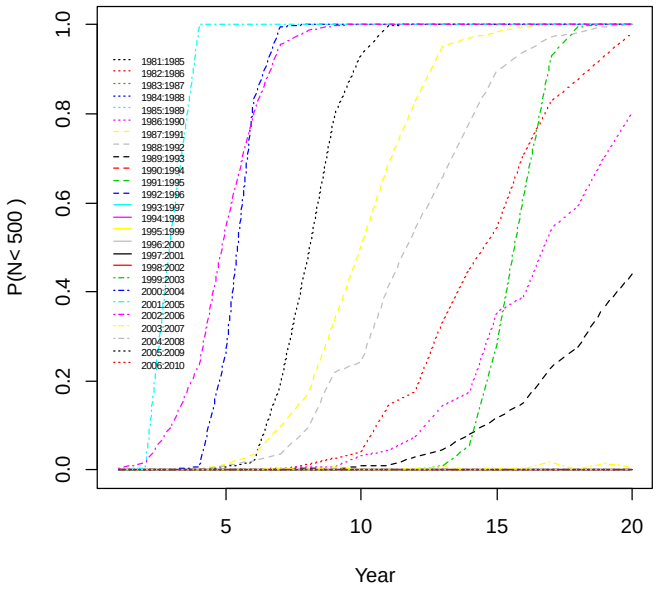
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010


Period: 5 years Threshold: 500
P(N< 500)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
1987:1991
1988:1992
1989:1993
1990:1994
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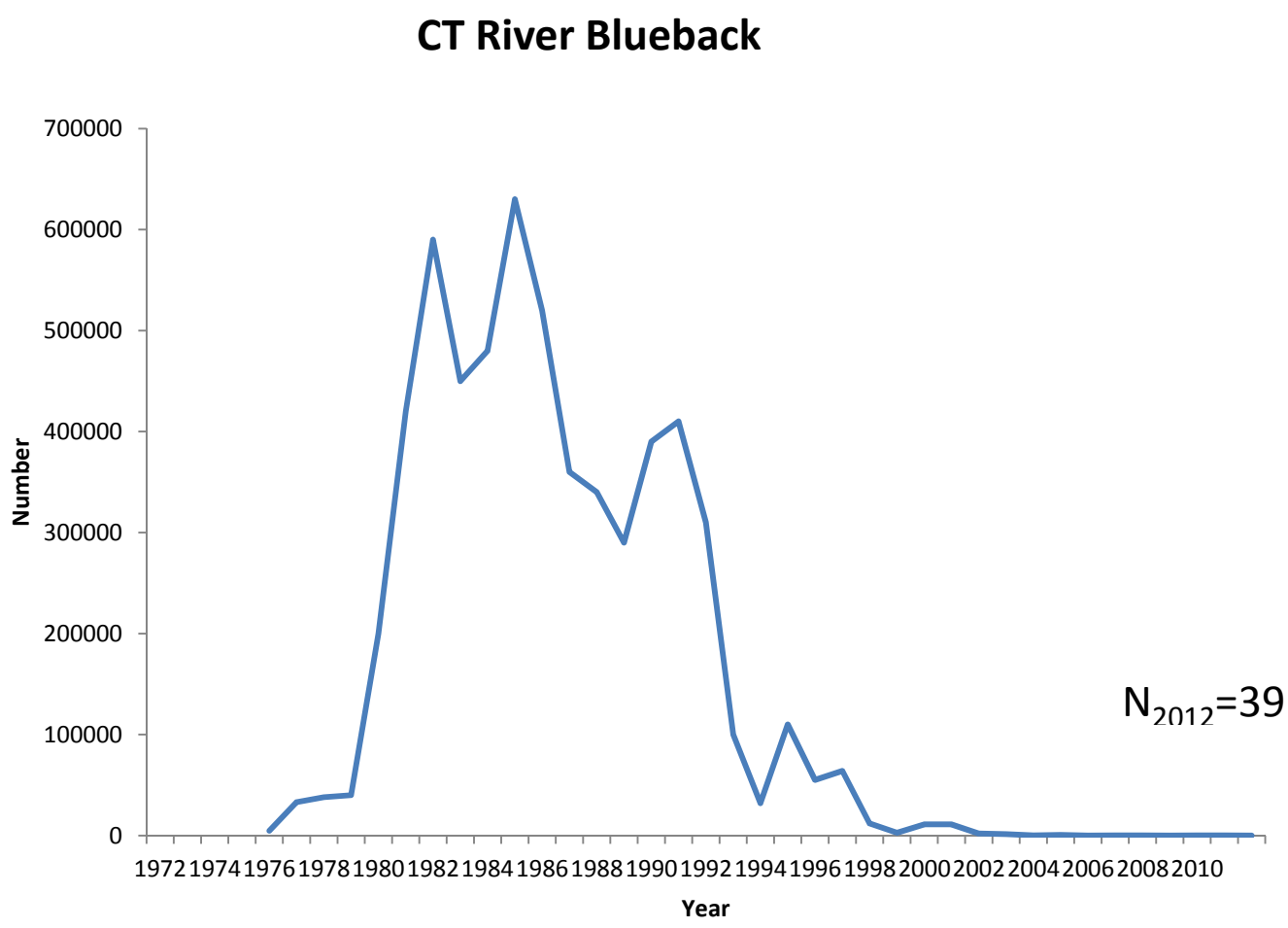
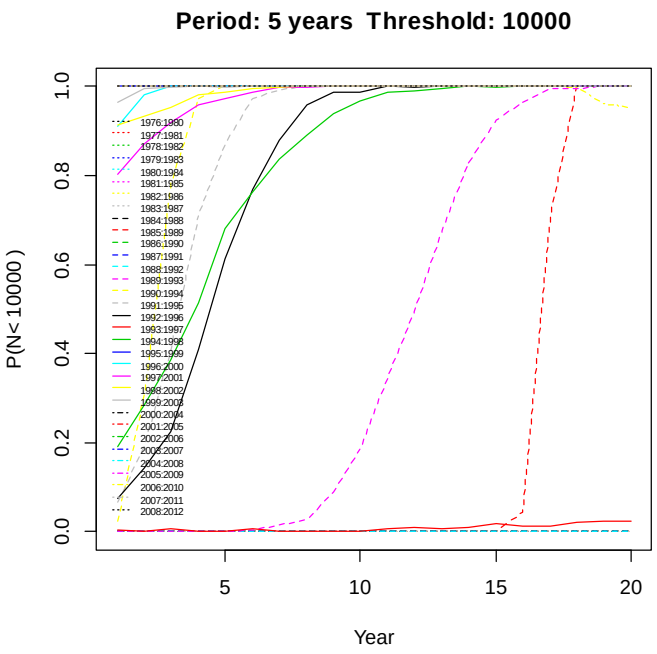
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010

Blueback Herring Examples


CT River Blueback
700000
600000
500000
400000
300000
200000
100000
0
Number
1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010
Year
N2012=39


Period: 5 years Threshold: 10000
P(N< 10000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1976:1980
1977:1981
1978:1982
1979:1983
1980:1984
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
1987:1991
1988:1992
1989:1993
1990:1994
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2000:2004
2001:2005
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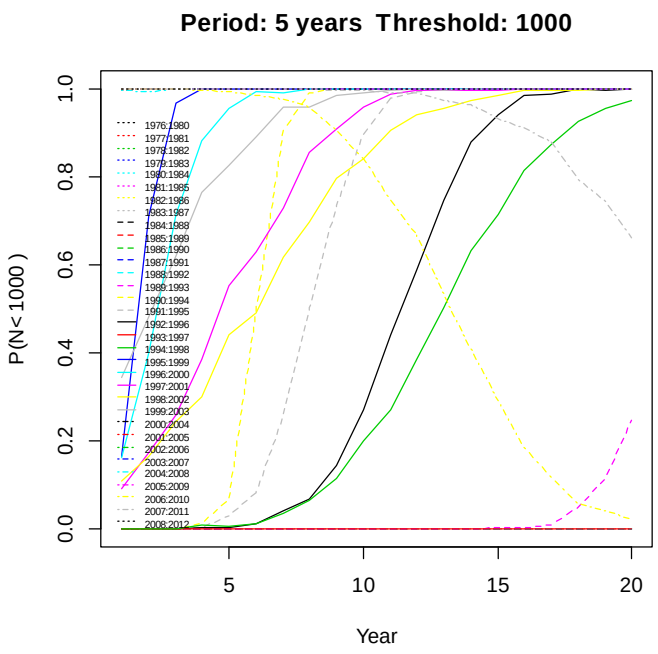
2003:2007
2004:2008
2005:2009
2006:2010
2007:2011
2008:2012


Period: 5 years Threshold: 1000
P(N< 1000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1976:1980
1977:1981
1978:1982
1979:1983
1980:1984
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
1987:1991
1988:1992
1989:1993
1990:1994
1991:1995
1992:1996
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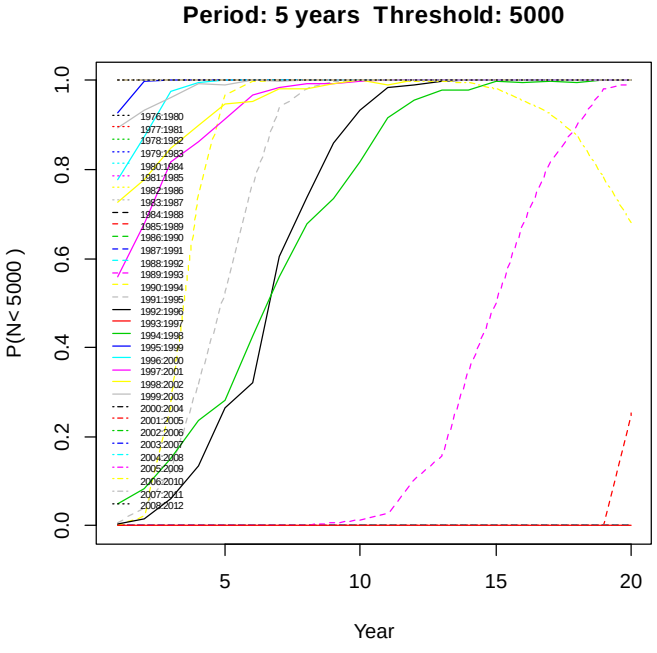
1996:2000
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009
2006:2010
2007:2011
2008:2012


Period: 5 years Threshold: 5000
P(N< 5000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1976:1980
1977:1981
1978:1982
1979:1983
1980:1984
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
1987:1991
1988:1992
1989:1993
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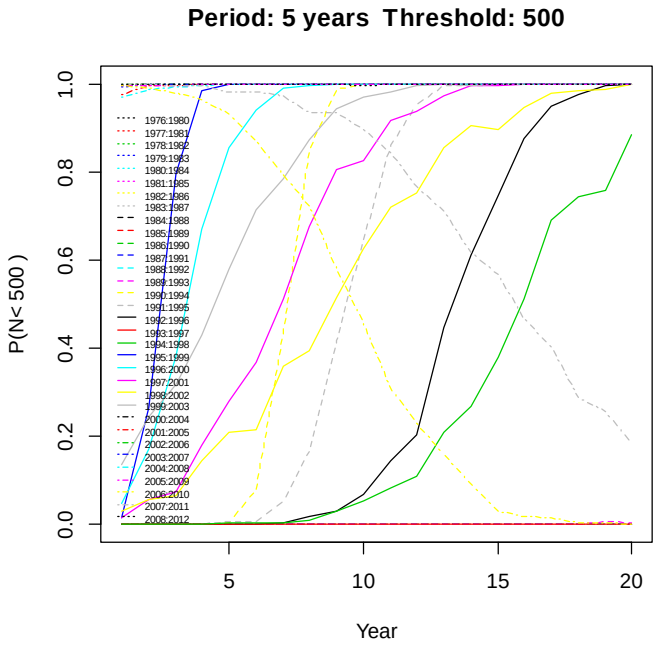
2005:2009
2006:2010
2007:2011
2008:2012


Period: 5 years Threshold: 500
P(N< 500)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1976:1980
1977:1981
1978:1982
1979:1983
1980:1984
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
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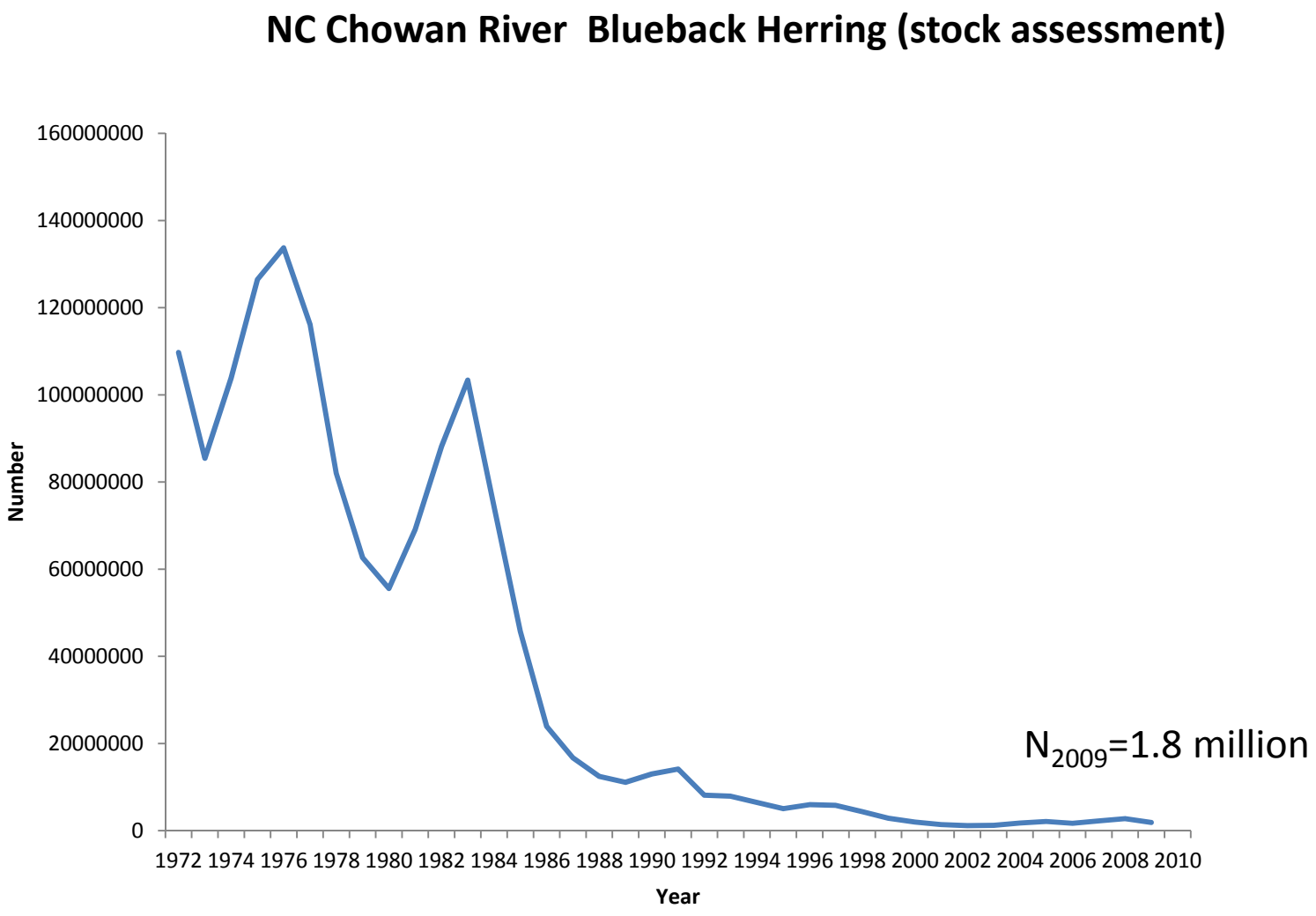
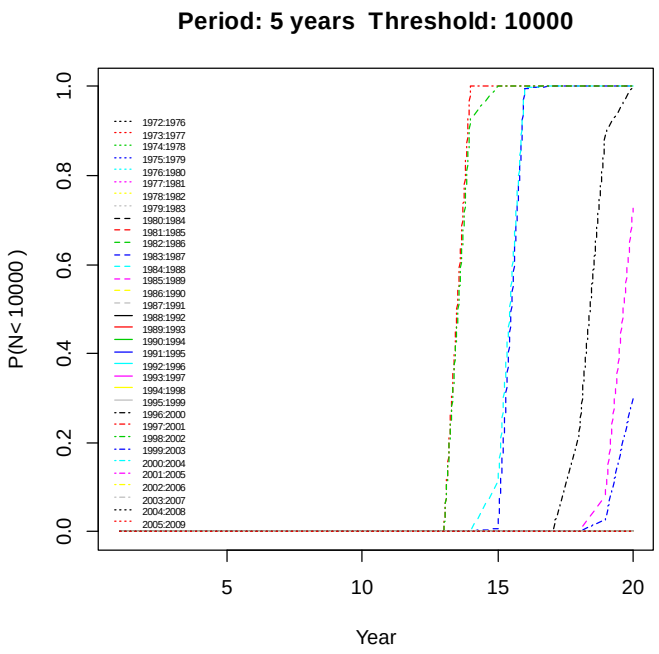
2003:2007
2004:2008
2005:2009
2006:2010
2007:2011
2008:2012


NC Chowan River Blueback Herring (stock assessment)
160000000
140000000
120000000
100000000
80000000
60000000
40000000
20000000
0
Number
1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010
Year
N_{2009}=1.8 million


Period: 5 years Threshold: 10000
P(N< 10000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1972:1976
1973:1977
1974:1978
1975:1979
1976:1980
1977:1981
1978:1982
1979:1983
1980:1984
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
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2000:2004
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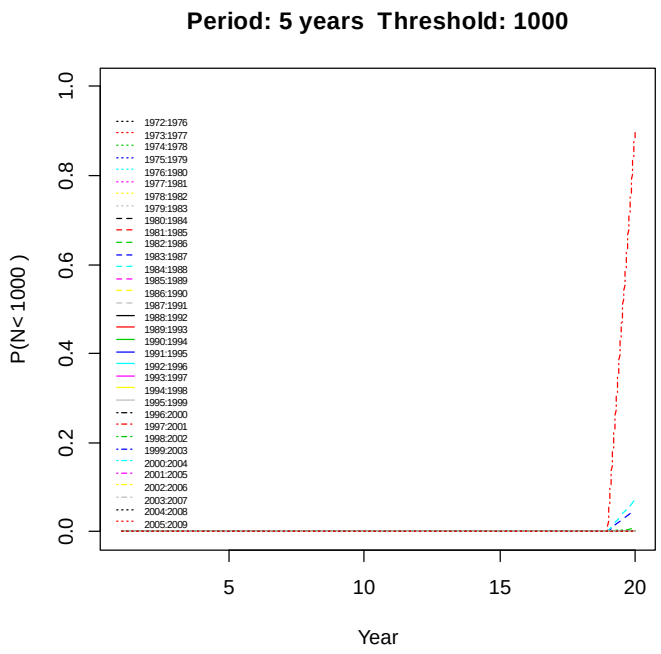
2002:2006
2003:2007
2004:2008
2005:2009


Period: 5 years Threshold: 1000
P(N< 1000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1972:1976
1973:1977
1974:1978
1975:1979
1976:1980
1977:1981
1978:1982
1979:1983
1980:1984
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
1987:1991
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2001:2005
2002:2006
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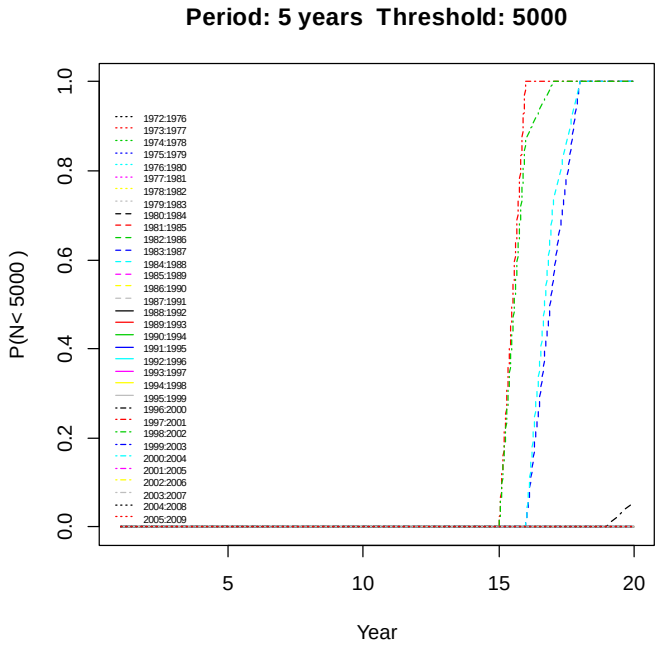
2005:2009


Period: 5 years Threshold: 5000
P(N< 5000)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1972:1976
1973:1977
1974:1978
1975:1979
1976:1980
1977:1981
1978:1982
1979:1983
1980:1984
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
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2003:2007
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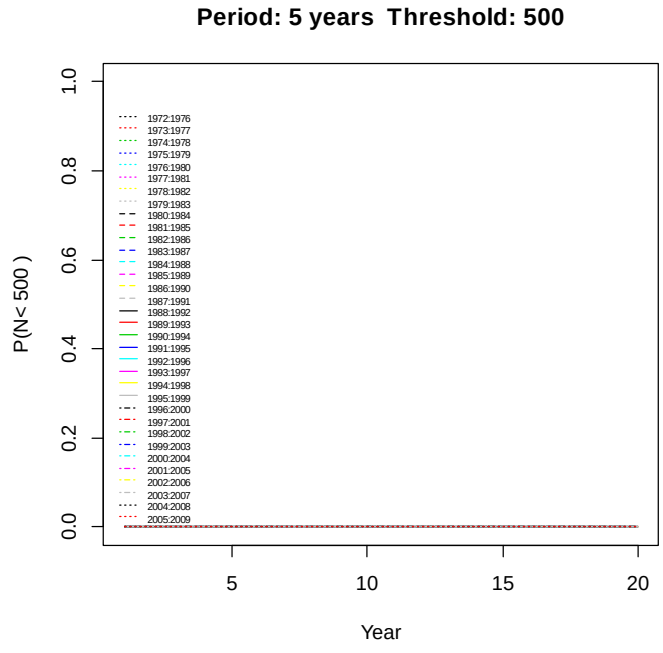
2005:2009


Period: 5 years Threshold: 500
P(N< 500)
Year
0.0
0.2
0.4
0.6
0.8
1.0
5
10
15
20
1972:1976
1973:1977
1974:1978
1975:1979
1976:1980
1977:1981
1978:1982
1979:1983
1980:1984
1981:1985
1982:1986
1983:1987
1984:1988
1985:1989
1986:1990
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1988:1992
1989:1993
1990:1994
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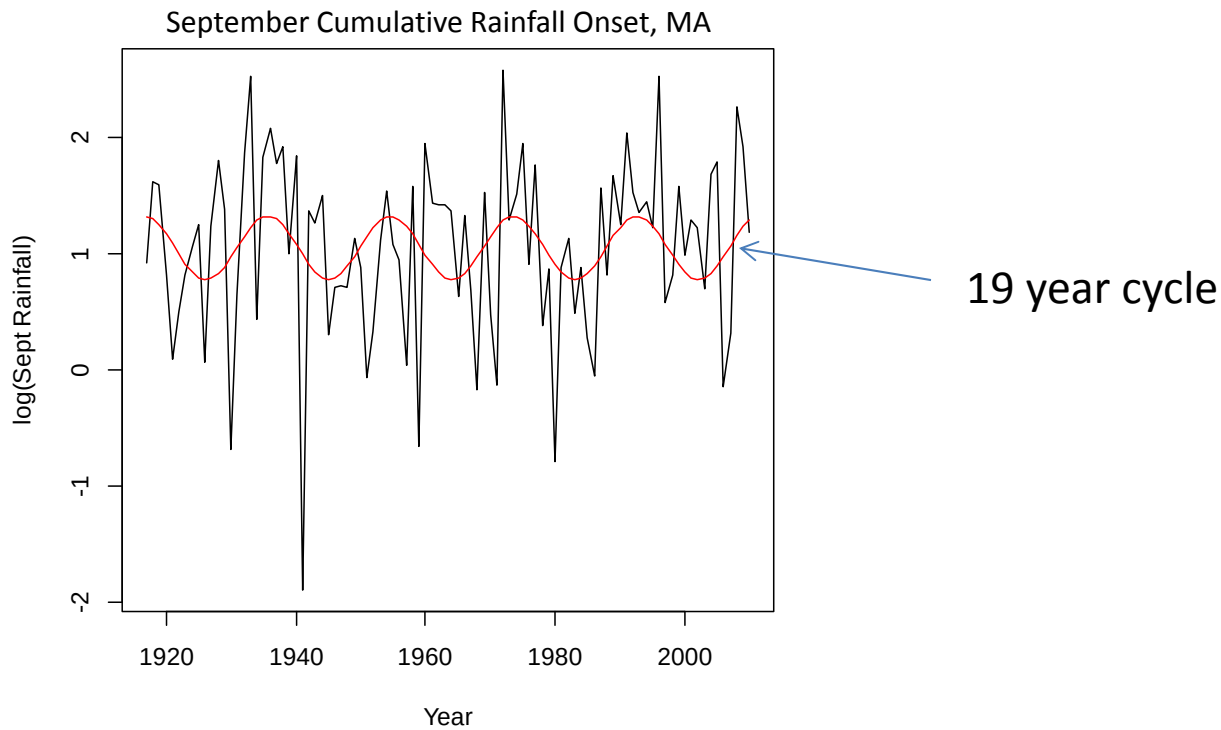
1995:1999
1996:2000
1997:2001
1998:2002
1999:2003
2000:2004
2001:2005
2002:2006
2003:2007
2004:2008
2005:2009

Method 2

1. Determine if environmental variables can explain variation in recruitment of stock assessment model (Deriso et al. 2008)

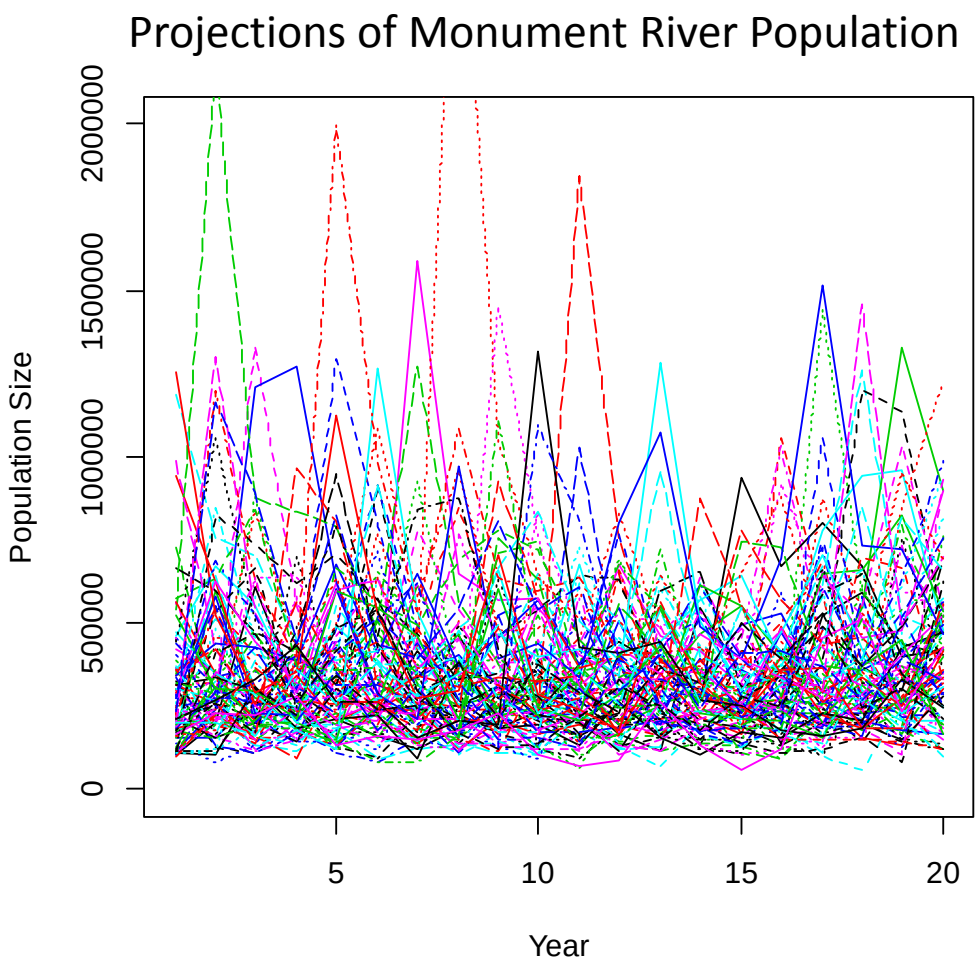
$$\hat{R}_y = \hat{R}_0 \cdot e^{\left(\sum_{i=1}^{n} \hat{\beta}_i X_{i,y} + \hat{\varepsilon}_y - 0.5\hat{\sigma}^2\right)}$$

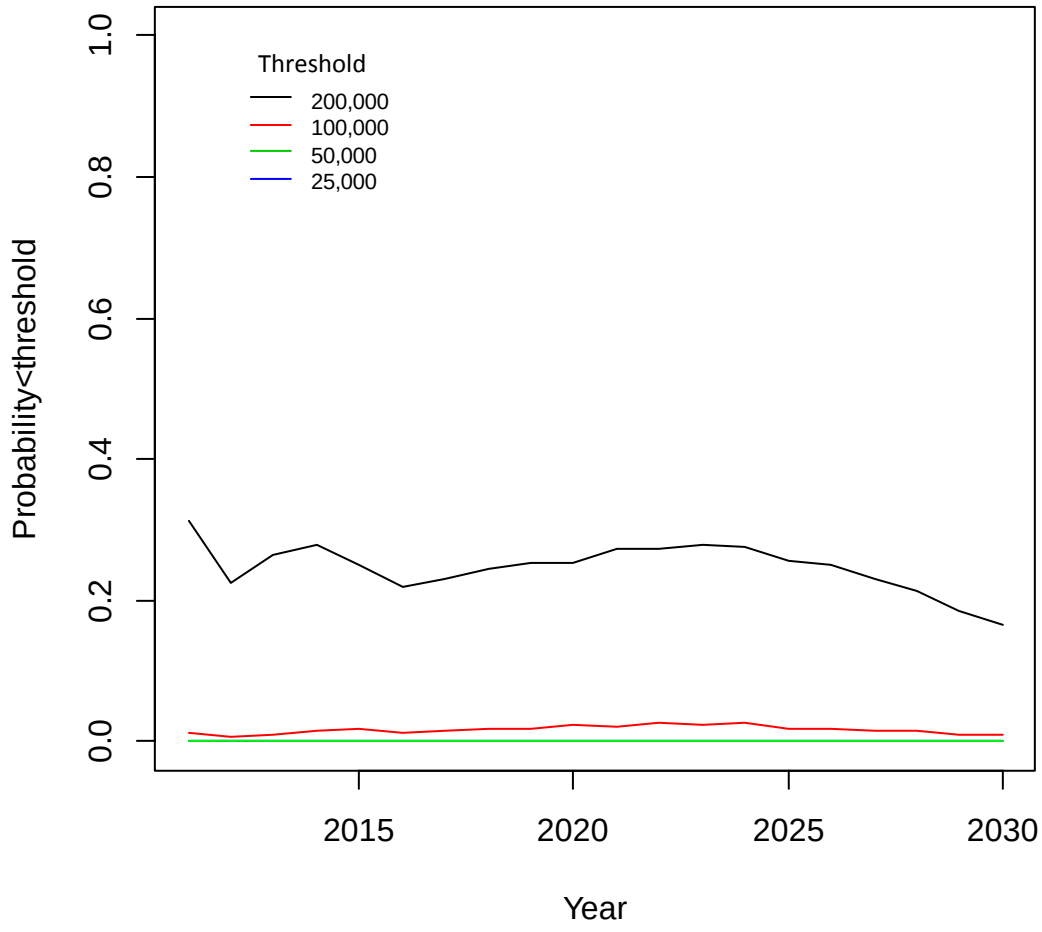
2. If significant, analyze environmental variables for time trends and project or get climate change predictions



Method 2

3. Project a population forward *d* years in time using error in starting N values, incorporating error and projected environmental variation in stock recruitment equation; repeat J times



4. Calculate probability of going below threshold *th* over *d* years

Probability of Monument River Population Going Below Thresholds