SAS files associated with Vadeboncoeur et al. 2008. Ecology.

\*8 February 2007

This program creates files that mimic the matlab code devised for the morphometry model by Peterson.

Our purpose is to trouble shoot some relationships seen in the revised model. The whole first part of the program

is a very clumsy way of creating morphometry files for all of our lake categories.

more stuff added 5 June 2007 to better determine area. Not sure if this is the most up to date program;

**data** master;

set morph.z10cm;

zmean=**2**;

DR=**0.3**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**data** add;

set morph.z10cm;

zmean=**2**;

DR=**0.5**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**2**;

DR=**0.7**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**5**;

DR=**0.3**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**5**;

DR=**0.5**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**5**;

DR=**0.7**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**10**;

DR=**0.3**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**10**;

DR=**0.5**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**10**;

DR=**0.7**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**25**;

DR=**0.3**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**25**;

DR=**0.5**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**25**;

DR=**0.7**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**100**;

DR=**0.3**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**100**;

DR=**0.5**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** add;

set morph.z10cm;

zmean=**100**;

DR=**0.7**;

Zmax=zmean/DR;

if z<zmax;

**run**;

**proc** **append** base=master data=add;

**run**;

**data** morph.morphoz;

set master;

gamma = DR/(**1**-DR);

LA = **0.28446**\*Zmean\*\***1.303**;\*LA=Lake area, from Vadeboncoeur data compilation. March 07;\*edited out 5 June2007 put back in 10 june;

\*Log\_LA=1.38442 + 1.2569\* Log10(zmean) - 2.8728\* Sqrt(DR);

\*LA=10\*\*Log\_LA;\*added 5 June 2007 to get a slightly better estimate of area from non deep world lakes;

Zt\_zmax = **0.475**\*Zmax\*\***0.715**; \* calculating thermocline depth (zt) from mzx depth Hanna 1990;

Zt\_LA =**6.95**\*LA\*\***0.185**; \*calculating thermocline depth from lake area from Hanna 1990

\* 6.95 x lake area ^ 0.185

\* where lake area is in km2;

\*LA = (gamma/(gamma+1))\*(DR^(1-gamma))\*Zmean^gamma;

AreaH = **1**-(Z/Zmax)\*\*gamma; \*area high is the fractional surface area of the lake at depth z;

AreaL = **1**-((Z+**0.1**)/Zmax)\*\*gamma; \*area low is the fractional surface area of the lake at depth z + 0.01;

AreaZ = (AreaH-AreaL); \*littoral surface area between z and z+0.1;

If z = zmax then AreaZ=**0**;

VolZ=(AreaH+AreaL)/**2**\***0.1**;\*Fraction of volume between depth z and z+0.1;

if AreaZ GE **0**;

**run**;

**proc** **sort**;

by zmean DR;

**run**;

**proc** **means**;

by zmean DR;

var areaz volz;

output out=test sum=;

**run**;

**proc** **print**;

**run**;

\*This part of the program creates and compiles files where TP = 3,5,10,25,50,100,500,1000 mg/m3.

These files are appended to each other to form one very long file. I truncate depth at 30m past the thermocline

in order to have fewer records.;

**data** thermotrunc;

set morph.morphoz;

**run**;

**data** master2;

set thermotrunc;

TP=**3**;

**run**;

**data** add2;

set thermotrunc;

TP=**5**;

**run**;

**proc** **append** base=master2 data=add2;

**run**;

**data** add2;

set thermotrunc;

TP=**10**;

**run**;

**proc** **append** base=master2 data=add2;

**run**;

**data** add2;

set thermotrunc;

TP=**25**;

**run**;

**proc** **append** base=master2 data=add2;

**run**;

**data** add2;

set thermotrunc;

TP=**50**;

**run**;

**proc** **append** base=master2 data=add2;

**run**;

**data** add2;

set thermotrunc;

TP=**100**;

**run**;

**proc** **append** base=master2 data=add2;

**run**;

**data** add2;

set thermotrunc;

TP=**500**;

**run**;

**proc** **append** base=master2 data=add2;

**run**;

**data** add2;

set thermotrunc;

TP=**1000**;

**run**;

**proc** **append** base=master2 data=add2;

**run**;

**data** morph.morpho\_TP;

set master2;

**run**;

\*\*\*\*\*\*\*step 1;

\*This part of the program tests for the effects background turbidity (Kb=0.05) and maximum benthic productivity

(BPmax = 5, 50, 120). A file is created for each possible combination and then benthic and pelagic productivity is summed over all

depths;

**data** pprup; \*Unfortunately we need to create separate files for above and below the thermocline because of the change in light

attenuation at the thermocline;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.05**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**5**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**data** morph.TPPRepi;

set TPPRepi;

drop \_type\_ \_freq\_;

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.05**;

K=(Kb+**0.015**\*chl2);

BPmax=**5**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**; \*only calculates ppr to 1% light;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**Data** morph.Tppr1p;

set tppr1p;

drop \_type\_ \_freq\_;

**run**;

\*\*\*\*step2, Bpmax=50;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.05**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**50**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.05**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**50**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step3, Bpmax=120;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.05**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**120**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.05**;\*sets background turbidity to 0.05, about what it is in crater lake;

K=(Kb+**0.015**\*chl2);

BPmax=**120**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step4, Bpmax=28.08TP^.242;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.05**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**28.08**\*TP\*\***.242**; \*sets maximum benthic production to be a function of tp mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**data** pprup;

set pprup;

BPmax=**28**;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.05**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**28.08**\*TP\*\***.242**; \*sets maximum benthic production to a function of TP;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**data** pprup;

set pprup;

BPmax=**28**;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*13 February 2007

This program should be run after bppr\_comp\_t05. it appends data to Tppr1p and tpprepi.

\*\*\*\*\*\*\*step 1;

\*This part of the program tests for the effects background turbidity (Kb=0.2) and maximum benthic productivity

(BPmax = 5, 50, 120). A file is created for each possible combination and then benthic and pelagic productivity is summed over all

depths

;

**data** pprup; \*Unfortunately we need to create separate files for above and below the thermocline because of the change in light

attenuation at the thermocline;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.2**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**5**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base = morph.tpprepi data=tpprepi(drop = \_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.2**;

K=(Kb+**0.015**\*chl2);

BPmax=**5**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step2, Bpmax=50;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.2**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**50**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.2**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**50**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step3, Bpmax=120;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.2**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**120**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.2**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**120**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step4, Bpmax=28.08TP^.242;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.2**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**28.08**\*TP\*\***.242**; \*sets maximum benthic production to be a function of tp mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**data** pprup;

set pprup;

BPmax=**28**;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.2**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**28.08**\*TP\*\***.242**; \*sets maximum benthic production to a function of TP;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**data** pprup;

set pprup;

BPmax=**28**;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*8 February 2007

This program creates files that mimic the matlab code devised for the morphometry model by Peterson.

Our purpose is to trouble shoot some relationships seen in the revised model. The whole first part of the program

is a very clumsy way of creating morphometry files for all of our lake categories.;

\*13 Feb 2007. This calculates production assuming a background turbidity of 0.8;

\*\*\*\*\*\*\*step 1;

\*This part of the program tests for the effects background turbidity (Kb=0.2) and maximum benthic productivity

(BPmax = 5, 50, 120). A file is created for each possible combination and then benthic and pelagic productivity is summed over all

depths

files are named according to the following arrays: Kb[0.05, 0.2, 0.8, 2.0], BPmax[5, 50, 120,TP ;

**data** pprup; \*Unfortunately we need to create separate files for above and below the thermocline because of the change in light

attenuation at the thermocline;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.8**;

K=(Kb +**0.015**\*chl2);

BPmax=**5**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.8**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**5**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step2, Bpmax=50;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.8**;

K=(Kb +**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**50**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates pelagic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.8**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**50**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step3, Bpmax=120;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.8**;

K=(Kb +**0.015**\*chl2);

BPmax=**120**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.8**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**120**;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step4, Bpmax=28.08TP^.242;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**0.8**;

K=(Kb +**0.015**\*chl2);

BPmax=**28.08**\*TP\*\***.242**; \*sets maximum benthic production to be a function of tp mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**data** pprup;

set pprup;

BPmax=**28**;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**0.8**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**28.08**\*TP\*\***.242**; \*sets maximum benthic production to a function of TP;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**data** pprup;

set pprup;

BPmax=**28**;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*13 February 2007

This program should be run after bppr\_comp\_t05.

\*\*\*\*\*\*\*step 1;

\*This part of the program tests for the effects background turbidity (Kb=2) and maximum benthic productivity

(BPmax = 5, 50, 120). A file is created for each possible combination and then benthic and pelagic productivity is summed over all

depths

files are named according to the following arrays: Kb[0.05, 0.2, 0.8, 2.0], BPmax[5, 50, 120,TP ;

**data** pprup; \*Unfortunately we need to create separate files for above and below the thermocline because of the change in light

attenuation at the thermocline;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**2**;

K=(Kb +**0.015**\*chl2);

BPmax=**5**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base = morph.tpprepi data=tpprepi(drop = \_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**2**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**5**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step2, Bpmax=50;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**2**;

K=(Kb +**0.015**\*chl2);

BPmax=**50**; \*sets maximum benthic production to 50 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**2**;

K=(Kb+**0.015**\*chl2);

BPmax=**50**; \*sets maximum benthic production to 50 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step3, Bpmax=120;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**2**;

K=(Kb +**0.015**\*chl2);

BPmax=**120**; \*sets maximum benthic production to 5 mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates pelagic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**2**;

K=(Kb+**0.015**\*chl2);

BPmax=**120**; \*sets maximum benthic production to 120 mgC/m2/h;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

\*\*\*\*step4, Bpmax=28.08TP^.242;

**data** pprup;

set morph.morpho\_TP;;

if z<=ZT\_LA; \*this uses the thermocline depth determined by lake area. The lake area is a function of mean depth. This is

somewhat problematic in that for any given mean depth, a different depth ratio should give a different surface area. However, the effect

of this on thermocline depth is probably limited;

Chl2 = **0.407**\*TP\*\***0.87**;\*This uses a TP to chl relationship derived by Prairie et al. 1989 so that chlorophyll doesn't go

incandescent at high TP concentrations;

ThermoMult=**1**;

Kb=**2**;

K=(Kb +**0.015**\*chl2);

BPmax=**28.08**\*TP\*\***.242**; \*sets maximum benthic production to be a function of tp mgC/m2/h;

PPmax=**2.2**\*chl2\*ThermoMult; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

BpprzT=**0**;

PpprzT=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = **1500**\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZT+(BPmax\*TANH(light\*exp(-K\*Z)/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZT +(PPmax\*TANH(light\*exp(-K\*Z)/**180**)); \*calculates benthic ppr at time t assuming an Ik of 180;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=**1500**\*exp(-k\*Z);

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**data** pprup;

set pprup;

BPmax=**28**;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tpprepi sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPRepi data=tpprepi (drop=\_type\_ \_freq\_);

**run**;

**data** pprlow;

set morph.morpho\_TP;;

if z>ZT\_LA;

ThermoMult=**5.5**\*exp(-**.1**\*TP)+**1**; \* how much more productive things are under thermocline as fn of TP.

Empiracally derived by garry based on YV's lit review;

Chl2 = (**0.407**\*TP\*\***0.87**)\*ThermoMult;

Kb=**2**;

K=(Kb+**0.015**\*chl2); \*sets background turbidity to 0.05, about what it is in crater lake;

BPmax=**28.08**\*TP\*\***.242**; \*sets maximum benthic production to a function of TP;

PPmax=**2.2**\*chl2; \*sets maximum phyte production as a function of chlorophyll and thermocline;

time=**0.25**;

Bpprzt=**0**;

Ppprzt=**0**;

do until (time =**15**);\*assumes a 15 h day;

light = (**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*sin(constant('pi')\*Time/**15**);

BPPRZT = BpprZt+(BPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**300**)); \*calculates benthic ppr at time t assuming an Ik of 300;

PPPRZT = PpprZt +(PPmax\*TANH(light\*exp(-K\*(Z-ZT\_LA))/**180**)); \*calculates benthic ppr at time t assuming an Ik of 300;

time=time+**0.25**;\*increments time by 15 minutes;

end;

lightznoon=(**1500**\*exp(-(kb+**0.015**\*chl2/ThermoMult)\*ZT\_LA))\*exp(-K\*(Z-ZT\_LA));

BPPRZ=BPPRZT/**4**;\*calculates daily benthic PPR times the area at depth. divided by 4 to account for 15 min.time;

PPPRZ=PPPRZT/**4**;\*calculates daily pelagic PPR times the volume at depth. divided by 4 to account for 15 min.time;

Bppr=BPPRz\*areaz;

Pppr=PPPRz\*volz;

if lightznoon >= **1.5**;

**run**;

**proc** **append** base=pprup data=pprlow;

**run**;

**Proc** **sort**;

by zmean DR TP;

**run**;

**data** pprup;

set pprup;

BPmax=**28**;

**run**;

**Proc** **means**;

by zmean DR TP BPmax Kb;

var Bppr Pppr areaz volz;

output out=Tppr1p sum=Bppr Pppr areaz volz;

**run**;

**proc** **append** base =morph.TPPR1p data=tppr1p (drop=\_type\_ \_freq\_);

**run**;

**data** morph.tppr1p;

set morph.tppr1p;

logtp=log10(TP);

Fbppr=bppr/(bppr+pppr);

**run**;

**data** morph.tpprepi;

set morph.tpprepi;

logtp=log10(TP);

Fbppr=bppr/(bppr+pppr);

**run**;