Stump, Richard J. W. (1994) ***Age determination and life-history characteristics of Acanthaster planci(L.)(Echinodermata:Asteroidea).*** **PhD thesis, James Cook University.**

REFERENCES

Amesbury, S.S. and M. Babin (1990)
Ocean temperature structure and the seasonality of pelagic fish species near Guam, Mariana Islands. Micronesica 23(2):131-138.

Anderson, H.A., J. Smith and R.H. Thomson (1965)
Naturally occurring quinones. Part VI. Synthesis of spinochrome D. J. Chem. Soc. (C) p.2141.

Anderson, H.A. and R.H. Thomson (1966)
Naturally occurring quinones. Part VII. Synthesis of spinochrome E. J. Chem. Soc. (C) p.426-428.

Antonelli, P.L. and N.D. Kazarinoff (1984)
Starfish predation of a growing coral reef community. J. theor. Biol. 107:667-684.

Antonelli, P., R. Bradbury, L. Hammond, R. Ormond, and R. Reichelt (1990)
The *Acanthaster* phenomenon: a modelling approach. Rapporteurs' report. In:- Proceedings of *Acanthaster* and the coral reef: a theoretical approach. Townsville. Springer-Verlag. Berlin. p.329-338.

Arnold, S.J. (1992)
Constraints on phenotypic evolution. Am. Nat. 140:S85-S107.

Ayling, A.M. and A.L. Ayling (1992)
Crown-of-thorns and coral trout density on three Central Section reefs, 1983 - 1989. GBRMPA Research Publication No. 15. 54pp.

Ayukai, T. (1992)
Resource availability to the larvae of the crown-of-thorns starfish in Great Barrier Reef waters: an overview. In: The possible causes and consequences of outbreaks of the crown-of-thorns starfish. Eds. U. Engelhardt and B. Lassig. GBRMPA workshop series No. 18. p.21-35.

Aziz, A. and Sukarno (1978)
Preliminary observations on living habitats of *Acanthaster planci* (Linnaeus) at Pulau Tikus, Seribu Islands. Mar. Res. Indonesia 17:121.

Babcock, R.C., G.D. Bull, P.L. Harrison, A.J. Heyward, J.K. Oliver, C.C. Wallace, and B.L. Willis (1986)
Synchronous spawnings of 105 scleractinian coral species on the Great Barrier Reef. Mar. Biol. 90:379-394.

Babcock, R.C. and C. N. Mundy (1992)
Reproductive biology, spawning and field fertilization rates of *Acanthaster planci*. In: Crown-of-thorns starfish on the Great Barrier Reef: reproduction, recruitment and hydrodynamics. Ed. C.R. Johnson. Aust. J. Mar. Freshwater Res. 43:9-18.

Baird, D.J., L.R. Linton and R.W. Davies (1986)
Life history evolution and post-reproductive mortality risk. J. Animal Ecol. 55:295-302.

Beamish, R.J. and G.A. McFarlane (1983)
The forgotten requirement for age validation in fisheries biology. Trans. Am. Fish Soc. 112:735-743.

Bell, G. (1980)
The costs of reproduction and their consequences. Am. Nat. 116:45-76.

Benzie, J.A.H. (1992)
Review of the genetics, dispersal and recruitment of crown-of-thorns starfish (*Acanthaster planci*). In "Crown-of-thorns starfish on the Great Barrier Reef:- Reproduction, Recruitment and Hydrodynamics". Ed. C.R. Johnson. Aust. J. Mar. Sci. Freshwater Res. 43:81-94.

Benzie, J.A.H. (1994)
Fertilization dynamics of crown-of-thorns starfish. In: Joint scientific conference on science, management and sustainability of marine habitats in the 21st century. AMSA, ACRS and ISRS. James Cook University of North Queensland. Townsville. Abstracts. p.4.

Benzie, J.A.H. and J.A. Stoddart (1992b)
The genetic structure of crown-of-thorns starfish (*Acanthaster planci*) in Australia. Mar. Biol. 112:119-130.

Bevelander, G. (1963)
Effect of tetracycline on crystal growth. Nature 198:1103.

Beverton, R.J.H. (1963)
Maturation, growth and mortality of clupeid and engraulid stocks in relation to fishing. Rapp. P. -V. Reun. Cons. Int. Explor. Mer. 154:44-67.

Beverton, R.J.H. and S.J. Holt (1959)
A review of lifespans and mortality rates of fish in nature and the relation to growth and other physiological characteristics. In: Ciba Foundation colloquia in ageing. V. The lifespan of animals. Churchill. London. p.142-177.

Birkeland, C. (1982)
Terrestrial runoff as a cause of outbreaks of *Acanthaster planci* (Echinodermata: Asteroidea). Mar. Biol. 69:175-185.

Birkeland, C. (1989)
The Faustian traits of the crown-of-thorns starfish. Am. Sci. 77:154-163.

Birkeland, C. and J.S. Lucas (1990)
Acanthaster planci: Major management problem of coral reefs. CRC Press. Boca Raton. 257pp.

Boyce, M.S. (1984)
Restitution of *r* and *K* selection as a model of density dependent natural selection. Ann. Rev. Ecol. Syst. 15:427-447.

Bradbury, R.H., L.S. Hammond, P.J. Moran and R.E. Reichelt (1985)
Coral reef communities and the crown-of-thorns starfish: evidence for qualitatively stable cycles. J. theor. Biol. 113:69-80.

Branham, J.M., Reed, S.A., Bailey, J.H. and J. Caperon (1971)
Coral eating sea stars *Acanthaster planci* in Hawaii. Science 172:1155-1157.

Buslé, J., G. Gonzalez, B. Fourcault and C. Chauvet (1990)
Données histologiques et histochimiques sur les lipopigments (lipofuscines) des gonades et du foie de *Cephalopholis argus*, mérou de Polynésie Française. In: Proc. ISRS Congress, Nouméa. p.41-46.

Calow, P. (1978)
Life cycles: an evolutionary approach to the physiology and reproduction, development and ageing. Chapman and Hall. London. 164pp.

Calow, P. (1979)
The cost of reproduction - a physiological approach. Biol. Rev. 54:23-40.

Calow, P. (1984)
Exploring the adaptive landscapes of invertebrate life cycles. Adv. Inv. Rep. 3:329-342.

Calow, P. and J.B. Jennings (1977)
Optimal strategies for the metabolism of reserve materials in microbes and Metazoa. J. theor. Biol. 65:601-603

Cameron, A.M. (1977)
Acanthaster and coral reefs: population outbreaks of a rare and specialised carnivore in a complex high-diversity system. In, Proc. 3rd Int. Coral Reef Symp. Vol. 1. Univ. of Miami. Rosentiel School of Marine and Atmospheric Sciences. p.193-199.

Cameron, A.M. and R. Endean (1981)

Renewed outbreaks of a rare and specialised carnivore (the starfish *Acanthaster planci*) in a complex high-diversity system (the Great Barrier Reef). In, The reef and man. Proc. 4th Int. Coral Reef Symp.. Manila. Univ. of the Philippines. p.593-596.

Chapman, D.G. (1952)
Inverse multiple and sequential sample census. Biometrics 8:286-306.

Charlesworth, B. (1980)
Evolution in age structured populations. Cambridge studies in mathematical biology I. Cambridge Univ. Press. Cambridge. 300pp.

Charlesworth, B. and J.A. Léon (1976)
The relation of reproductive effort to age. Am. Nat. 110:449-459.

Charnov, E.L. (1993)
Life history invariants: some explorations of symmetry in evolutionary ecology. Oxford University Press. Oxford. 167pp.

Charnov, E.L. and W.M. Schaffer (1973)
Life history consequences of natural selection: Cole's result revisited. Am. Nat. 107:791-793.

Charnov, E.L. and D. Berrigan (1990)
Dimensionless numbers and life history evolution: age at maturity versus adult lifespan. Evol. Ecol. 4:273-275.

Charnov, E.L. and D. Berrigan (1991)
Dimensionless numbers and the assembly rules for life histories. Phil. Trans. Roy. Soc. B 332:41-48.

Cheke, R.A. (1978)
Theoretical rates of increase of gregarious and solitarious populations of the desert locust. Oecologia. 35:161-171.

Cheney, D.P. (1972b)
Spawning and aggregation of *Acanthaster planci*. In: Proc. U. of Guam Trust Territory *Acanthaster planci* (crown-of-thorns starfish) Workshop. Ed. R.T. Tsuda. Univ. Guam Mar. Lab. Tech. Rep. 3:11.

Cheney, D.P. (1974)
Spawning and aggregation of *Acanthaster planci* in Micronesia. In, Proc. 2nd Int. Symp. on Coral Reefs. Eds. Cameron, A.M. et al. Vol. 1. Brisbane. p.591-594.

Chesher, R.H. (1969a)

Divers wage war on the killer star. Skin Diver Mag. Reprint from March Issue. Petersen Publishing Co. USA. 3pp.

Chesher, R.H. (1969b)
Acanthaster planci impact on Pacific coral reefs. Final Report Res. Westinghouse Electric Corp. to U.S. Dept. Interior. 151pp.

Clarke, A., M.A. Kendall and D.J. Gore (1990)
The accumulation of fluorescent age pigments in the trochid gastropod *Monodonta lineata*. J. Exp. Mar. Biol. Ecol. 144:185-204.

Cole, L.C. (1954)
The population consequences of life history phenomena. Quart. Rev. Biol. 29:103-37.

Conand, C. (1983)
Abondance, cycle sexuel et relations biometriques de l'etoile *Acanthaster planci* en Nouvelle-Caledonie. Office de la recherche scientifique et technique outre-mer. Centre de Nouméa Oceanographie. 42pp.

Conand, C. (1984)
Distribution, reproductive cycle and morphometric relationships of *Acanthaster planci* (Echinodermata: Asteroidea) in New Caledonia, western tropical Pacific. In: Proc. 5th Int. Echin. Conf., Galway. Balkema. Rotterdam. p.499-506.

Crossland, C.J., G. Denby, B.F. Phillips and R. Brown (1990)
The use of fluorescent pigments (lipofuscin) for ageing western rock lobster (*Panulirus cygnus*) and scampi (*Metanephrops andamanicus*): a preliminary assessment. CSIRO Mar. Lab. Rep. No. 195, 21pp.

Crump, R.G. and R.H. Emson (1978)
Some aspects of the population dynamics of *Asterina gibbosa* (Asteroidea). J. mar. biol. Ass. U.K. 58:451-466.

Dana, T.F., W.A. Newman and E.W. Fager (1972)
Acanthaster aggregations: interpreted as primarily responses to natural phenomena. Pac. Sci. 26:355-372.

Dapson, R.W. (1980)
Guidelines for statistical usage in age estimation technics. J. Wildl. Manage. 44(3):541-548.

Davenport, S. and R. McLoughlin (1993)
Preliminary assessment of the distribution and the potential impact of the introduced starfish *Asterias amurensis* in Tasmanian waters. Status report to Fisheries Research and Development Corporation. CSIRO Div. of Fisheries. 38pp.

.erty, P.J. and J. Davidson (1988)
Monitoring the distribution and abundance of juvenile *Acanthaster planci* in the central Great Barrier Reef, in Proc. 6th Int. Coral Reef Symp. Townsville. Vol. 2, p.131-136.

Dubois, P. and C-P. Chen (1989)
Calcification in echinoderms. In: Echinoderm Studies Vol. 3:109-178.

Dubois, P. and M. Jangoux (1984)
The microstructure of the asteroid skeleton (*Asterias rubens*). Proc. 5th Int. Echinoderm Conf. Galway. p.507-512.

Dunbrack, R.LeB. and D.M. Ware (1987)
Energy constraints and reproductive trade-offs determining body size in fishes. In: Evolutionary Physiological Ecology. Ed. P. Calow. Cambridge University Press. p.191-218.

Ebert, T.A. (1967)
Negative growth and longevity in the purple sea urchin *Strongylocentrotus purpuratus* (Stimpson). Science 157:557-558.

Ebert, T.A. (1968)
Growth rates of the sea urchin *Strongylocentrotus purpuratus* related to the food availability and spine abrasion. Ecology. 49(6):1075-1091.

Ebert, T.A. (1973)
Estimating growth and mortality rates from size data. Oecologia 11:281-298.

Ebert, T.A. (1975)
Growth and mortality of post-larval echinoids. Am. Zool. 15:755-775.

Ebert, T.A. (1982)
Longevity, life history, and relative body wall size in sea urchins. Ecol. Monogr. 52(4):353-394.

Ebert, T.A. (1983)
Recruitment in echinoderms. In, Echinoderm Studies. Vol. 1:169-202.

Ebert, T.A. (1984)
The non-periodic nature of growth rings in echinoid spines. In: Proc. 5th. Int. Echin. Conf., Galway. Balkema. Rotterdam. p.261-267.

Ebert, T.A. (1986)
A new theory to explain the origin of growth lines in sea urchin spines. Mar. Ecol. Prog. Ser. 34:197-199.

Eldred, G.E., G.V. Miller, W.S. Stark and L. Feeney-Burns (1982)
Lipofuscin: resolution of discrepant fluorescence data. Science 216:757-758.

Endean, R. (1969)
Report on investigations made into aspects of the current *Acanthaster planci* (Crown-of-Thorns) infestations of certain reefs of the Great Barrier Reef. Qld. Dept. Primary Industries, Fisheries Branch, Brisbane. 30pp.

Endean, R. and W. Stablum (1973b)
A study of some aspects of the Crown-of-Thorns starfish (*Acanthaster planci*) infestations of reefs of Australia's Great Barrier Reef. Atoll. Res. Bull. 167:1-62.

Endean, R. (1974)
Acanthaster planci on the Great Barrier Reef. In: Proc. 2nd Int. Coral Reef Symp. Vol. 1. p.563-576.

Endean, R. (1977)
Acanthaster planci on the Great Barrier Reef. In, Proc. 3rd Int. Coral Reef Symp. Vol. 1. p.185-191.

Feder, H. (1970)
Growth and predation by the ochre sea star, *Pisaster ochraceus* (Brandt) in Monterey Bay, California. Ophelia 8:161-185.

Feder, H. and A.M. Christiansen (1966)
Aspects of asteroid biology. In, Physiology of Echinodermata. Ed. R.A. Boolootian. Interscience Publ. New York. p.87-127.

Gadgil, M. and W. Bossert (1970)
Life history consequences of natural selection. Am. Nat. 104:1-24.

Giesel, J.T., P.A. Murphy and M.N. Manlove (1982b)
An investigation of the effects of temperature on the genetic organisation of life history indices in three populations of *Drosophila melanogaster*. In, Evolution and genetics of life histories. Eds. H. Dingle and J.P. Hegmann. Springer-Verlag. New York. p.189-207.

Gillespie, J.H. (1981)
The role of migration in the genetic structure of populations in temporally and spatially varying environments. III. Migration modification. Am. Nat. 117:223-233.

Glynn, P.W. (1982b)
Individual recognition and phenotypic variability in *Acanthaster planci* (Echinodermata: Asteroidea). Coral Reefs. 1:89-94.

Goreau, T.F. (1964)
On the predation of coral by the spiny starfish *Acanthaster planci* (L.) in the southern Red Sea, Israel South Red Sea Expedition, 1962. Reports. Bull. Sea Fish. Res. Stn. Israel. 35:23-26.

Gould, S.J. (1966)
Allometry and size in ontogeny and phylogeny. Biol. Rev. 41:587-640.

Gould, S.J. and R.C. Lewontin (1979)
The spandrels of San Marco and the Panglossian paradigm: a critique of the adaptationist programme. Proc. R. Soc. Lond. B 205:581-598.

Grahame, J. and G.M. Branch (1985)
Reproductive patterns of marine invertebrates. Oceanogr. Mar. Biol. Ann. Rev. 23:373-398.

Grime, J.P. (1977)
Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. Am. Nat. 111:1169-1194.

Gross, L.J. (1986)
Ecology: an idiosyncratic view. In: Mathematical Ecology. Biomathematics Vol. 17. Eds. T.G. Hallam and S.A. Levin. Springer-Verlag. Berlin. p.3-15.

Gulland, J.A. and S.J. Holt (1959)
Estimation of growth parameters for data at unequal time intervals. J. Cons. perm. int. Explor. Mer. 25:47-49.

Habe, T., G. Yamamoto, A. Ngai, M. Kosaka, M. Ogura, S. Sawamoto, S. Ueno and H. Yokochi (1989)
Studies on the conservation and management of coral reefs and the control of *Acanthaster planci* juveniles. Report of Grant-in-Aid for Scientific Research. Ministry of Education, Science and Culture. Japan (in Japanese).

Heatfield, B.M. (1971)
Growth o the calcareous skeleton during regeneration of spines of the sea urchin, *Stronglyocentrotus purpuratus* (Stimpson): a light and scanning electron microscopy study. J. Morph. 134:57-90.

Hill, K. T. and R.L. Radke (1988)
Gerontological studies of the damselfish, *Dascyllus albisella*. Bull. Mar. Sci. 42(3):424-434.

Hill, K.T. and C. Wommersley (1991)
Critical aspects of fluorescent age-pigment methodologies: modification of accurate analysis and age assessments in aquatic organisms. Mar. Biol. 109:1-11.

Horn, H.S., J.T. Bonner, W. Doyle, M.J. Katz, M.A.R. Koehl, H. Meinhardt, .A. Raff, W.E. Reif, S.C. Stearns and R. Strathmann (1982).
Adaptive aspects of development. In: Evolution and development. Report of the Dahlem Workshop on Evolution and Development. Berlin. May 10 - 15, 1981. Ed. J.T. Bonner. Springer-Verlag. p.215-235.

Houston, A.I. and J.M. McNamara (1992)
Phenotypic plasticity as a state-dependent life history decision. Evol. Ecol. 6:243-253.

Istock, C.A. (1983)
The extent and consequence of heritable variation for fitness characters. In, Population biology: retrospect and prospect. Eds. King, C.E. and P.S. Dawson. Columbia Univ. Press. New York. p.61-96.

James, M.K., I.J. Dight and L. Bode (1990)
Great Barrier Reef hydrodynamics, reef connectivity and *Acanthaster* population dynamics. In: *Acanthaster* and the coral reef: a theoretical perspective. Ed. R.H. Bradbury. (Lecture Notes in Biomathematics; 88). Berlin: Springer-Verlag. p. 17-44.

Jangoux, M., P. Dubois, A. Lambert and C. Yourassowsky (1984)
Coelomic microcanaliculae within the asteroid body wall. In: Proc. 5th Int. Echin. Conf., Galway. Balkema. Rotterdam. p.593.

Johnson D.B., D.K. Bass, B.A. Miller-Smith, P.J. Moran, C.N. Mundy and P.J. Speare (1988)
Outbreaks of crown-of-thorns starfish (*Acanthaster planci*) on the Great Barrier Reef: results of surveys 1986-1988 In: Proceedings of the 6th Int Coral Reef Symp. Eds. Choat J.H. et al. Townsville. Australia. 2:165-169.

Jones, R. and C. Johnston (1977)
Growth, reproduction and mortality in gadoid fish species. In: Fisheries Mathematics, Ed. J.H. Steele. Academic Press. London. p.37-62.

Kaitala, A. (1991)
Phenotypic plasticity in reproductive behaviour of waterstriders: trade-offs between reproduction and longevity during food stress. Functional Ecology. 5:12-18.

Kawecki, T.J. and S.C. Stearns (1993)
The evolution of life histories in spatially heterogeneous environments: optimal reaction norms revisited. Evol. Ecol. 7:155-174.

Keesing, J.K. (1990)
Aspects of the feeding biology of the crown-of-thorns starfish, *Acanthaster planci* (Linnaeus). PhD thesis. Zoology Dept. James Cook University of North Queensland. 197pp.

Keesing, J.K. and J.S. Lucas (1992)
Field measurements of feeding and movement rates of the crown-of-thorns starfish *Acanthaster planci* (L.). J. Exp. Mar. Biol. Ecol. 156:89-104.

Kenchington, R.A. (1977)
Growth and recruitment of *Acanthaster planci* (L.) on the Great Barrier Reef. Biol. Conserv. 5:11-20.

Kettle, B.T. (1990)
Variations in biometric and physiological parameters of *Acanthaster planci* (L) (Echinodermata; Asteroidea) during the course of a high de*p+1 ring the course of a high thesis Zoology Dept. James Cook University of North Queensland. 180pp.

Kettle, B.T. and J.S.Lucas (1987)
Size related morphological and physiological phenomena in *Acanthaster planci* (L.). (Echinodermata: Asteroidea). Bull. Mar. Sci. 41:541-551.

Kirkwood, T.B.L. and R. Holliday (1979)
The evolution of ageing and longevity. Proc. Royal Soc. Lond. (Section B) 205:531-546.

Kleiber, M. (1961)
The fire of life: an introduction to animal energetics. Wiley Press. New York.

Koltsova, G., L.V. Boguslavskaya and O.B. Maximov (1981)
On the functions of quinonoid pigments in sea urchin embryos. Int. Journal of Inv. Rep. 4:17-23.

Kozłowski, J. (1993)
Measuring fitness in life history studies. TREE 8(3):84-85.

Knight, W. (1968)
Asymptotic growth: an example of nonsense disguised as mathematics. J. Fish. Res. Bd. Canada. 25(6):1303-1307.

Lawrence, J.M. (1976)
Patterns of lipid storage in post-metamorphic marine invertebrates. Am. Zool. 16:747-762

Lawrence, J.M. (1979)
Growth rings in the ossicles of *Nidorellia armata* (Asteroidea: Oreasteridae). Florida Scientist. 42:24.

Lawrence, J.M. (1984)
The energetic echinoderm. Proc. 5th Int. Echin. Conf., Galway. Balkema. Rotterdam. p.47-67.

Lawrence, J.M. (1987a)
Echinodermata. In, Animal Energetics. Vol. 2, Chapt. 5. Bivalvia through Reptilia. Eds. Pandian, T.J. and F.J. Vernberg. Academic Press. San Diego. p.229-320.

Lawrence, J.M. (1987b)
A functional biology of echinoderms. Johns Hopkins Univ. Press. 331pp.

Lawrence, J.M. (1988)
Functional consequences of the multiarmed condition in asteroids. In: Echinoderm Biology. Proc. 6th Int. Echinoderm Conf. Eds. R.D. Burke, P.V. Mladenov, P. Lambert and R.L. Parsley. A.A. Balkema. Rotterdam. p.597-602.

Lawrence J.M. (1990)
The effect of stress and disturbance on echinoderms Zoo. Sci. 7:17-28

Lawrence, J.M. (1991)
Analysis of characteristics of echinoderms associated with *stress*. In: Biology of Echinodermata. Eds. T. Yanagisawa, I. Yasumasu, C. Oguro, N. Suzuki, and T. Motokawa. Balkema. Rotterdam. p.11-26.

Lawrence, J.M. (1992)
Arm loss and regeneration in Asteroidea (Echinodermata). Echinoderm Research. Eds. L. Scalera-Liaci and C. Canicatti. Balkema. Rotterdam. p.39-52.

Lawrence, J.M. and J.M. Lane (1982)
The utilisation of nutrients by post-metamorphic echinoderms. In: Echinoderm Nutrition. Eds. M.Jangoux and J.M. Lawrence. Balkema. Rotterdam. p.331-371.

Lawrence, J.M. and P. Moran (1992)
Proximate composition and allocation of energy to body components in *Acanthaster planci* (Linnaeus) (Echinodermata: Asteroidea). Zoo. Sci. 9:321-328.

Laxton, J.H. (1974)
Aspects of the ecology of the coral eating starfish *Acanthaster planci*. Biol. J. Linn. Soc. 6:19-45.

Levins, R. (1968)
Evolution in changing environments. Princeton Univ. Press. Princeton. 120pp.

Levitan, D.R. (1988)
Density-dependent size regulation and negative growth in the sea urchin *Diadema antillarum* (Phillipi). Oecologia 76:627-629.

Lewontin, R.C. (1965)
Selection for colonising ability. In: The genetics of colonising species. Eds. H.G. Baher and G.L. Stebbins. Academic Press. New York. p. 77-94.

Lotka, A.J. (1925)
Elements of physical biology. Williams and Wilkins. Baltimore.

Lucas, J.S. (1973)
Reproductive and larval biology of *Acanthaster planci* in Great Barrier Reef waters Micronesica 9:197-207.

Lucas, J.S. (1982)
Quantitative studies of feeding and nutrition during larval development of the coral reef asteroid *Acanthaster planci* (L.). J. Exp. Mar. Biol. Ecol. 65:173-193.

Lucas, J.S. (1984)
Growth, maturation and effects of diet in *Acanthaster planci* (L.) (Asteroidea) and hybrids reared in the laboratory. J. Exp. Mar. Biol. Ecol. 79:129-147

Lucas, J.S. and M.M. Jones (1976)
Hybrid crown-of-thorns starfish (*Acanthaster planci* X *A. brevispinus*) reared to maturity in the laboratory. Nature (London). 263:409-412.

MacArthur, R.H. (1962)
Some generalised theorems of natural selection. Proc. Natl. Acad. Sci. USA 48:1893-1897.

MacArthur, R.H. and E.O. Wilson (1967)
The theory of island biogeography. Monographs of population biology I. Princeton Univ. Press. Princeton, New Jersey. 203pp.

McCallum, H.I. (1990)
Effects of predation on *Acanthaster*: age structured metapopulation models. In: Bradbury, R.H., ed. *Acanthaster* and the coral reef: a theoretical perspective. (Lecture Notes in Biomathematics; 88). Berlin: Springer-Verlag. p.208-219.

McCallum, H.I., R. Endean, A.M. Cameron (1989)
Sublethal damage to *Acanthaster planci* as an index of predation pressure. Mar. Ecol. Prog. Ser. 56:29-36.

McKnight, D.G. (1978)
Acanthaster planci (L.) at the Kermadec Islands. N.Z. Oceanogr. Inst. Records. 4(3):17-19.

McRae, A. (1959)
Evechinus chloroticus (Val.), an endemic New Zealand echinoid. Trans. R. Soc. N.Z. 86:205-267.

Maynard Smith, J. (1989)
Evolutionary genetics. Oxford Univ. Press. Oxford. 319pp.

Mayr, E. (1963)
Animal species and evolution. Belknap Press. Cambridge, Massachusetts. 756pp.

Marcus, N.H. (1980)
Genetics of morphological variation in geographically distinct populations of the sea urchin *Arbacia punctulata* (Lamarck). J. exp. mar. Biol. Ecol. 43:121-130.

Marcus, N.H. (1983)
Phenotypic variability in echinoderms. Echinoderm studies 1:19-37.

Medawar, P.D. (1957)
The uniqueness of the individual. Methuen. London.

Menge, B.A. (1974)
Effects of wave action and competition on brooding and reproductive effort in a rocky intertidal starfish, *Leptasterias hexactis*. Ecology 55:84-93.

Mertz, D.B. (1975)
Senescent decline in flour beetle strains selected for early adult fitness. Physiol. Zoo. 48:1-23.

Michod, R.E. (1979)
Evolution of life histories in response to age-specific mortality factors. Am. Nat. 113:531-550.

Moore, G.P. (1966)
The use of trabecular bands as growth indicators in spines of the sea urchin *Heliocidaris erythrogramma*. Aust J. Sci. 29:52-54.

Moore, R.J. (1978)
Is *Acanthaster* an *r* strategist? Nature. 281:632.

Moore, R.J. (1990)
Persistent and transient populations of the crown-of-thorns starfish, *Acanthaster planci*. In: Bradbury, R.H., ed. *Acanthaster* and the coral reef: a theoretical perspective. (Lecture Notes in Biomathematics; 88). Berlin: Springer-Verlag. p. 236-277.

Moore, R.J. and A.C. Campbell (1984)
An investigation into the behavioural and ecological bases for periodic infestations of *Asterias rubens*. Proc. 5th Int. Echin. Conf., Galway. Balkema. Rotterdam. p.596.

Moran, P.J. (1986)
The *Acanthaster* phenomenon. Oceanogr. and Mar. Biol.: an annual review. Ed. M. Barnes. 24:379-480.

Moran, N.A. (1992)
The evolutionary maintenance of alternative phenotypes. Am. Nat. 139(5):971-989.

Moran, P.J., R.H. Bradbury and R.E. Reichelt (1988)
Distribution of recent outbreaks of the crown-of-thorns starfish (*Acanthaster planci*) along the Great Barrier Reef: 1985-1986 Coral Reefs 7:125-137

Motokawa, T. (1986)
Morphology of spines and spine joint in the Crown-of-Thorns starfish *Acanthaster planci* (Echinodermata, Asteroidea). Zoomorphology. 106:247-253.

Mueller, L.D. (1988a)
Density-dependent population growth and natural selection in food-limited environments: the *Drosophila* model. Am. Nat. 132:786-809.

Murphy, G.S. (1968)
Pattern in life history and the environment. Am. Nat. 102:391-403.

Nauen, C.N. (1982)
A review of data on respiration of starfish and their potential use for defining starfish growth and ecological role. Kiel. Meeresforsch. 29:1102-113.

Nauen, C.E. and L. Böhm (1979)
Skeletal growth in the echinoderm *Asterias rubens* (L.) Asteroidea: Echinodermata) by ^{45}Ca-labelling. J. Mar. Biol. Ecol. 38:261-269.

Nakamura, R. (1986)
A morphometric study on *Acanthaster planci* (L.) populations in the Ryukyu Islands. Galaxea. 5:223-237.

Nash, W.J. (1983)
Population genetic and morphometric studies on the crown-of-thorns starfish, *Acanthaster planci* (L.) in the Great Barrier Reef region. MSc thesis. Zoology Dept. James Cook University of North Queensland. 163pp.

Nicol, S. (1987)
Some limitations on the use of the lipofuscin ageing technique. Mar. Biol. 93:609-614.

Nishibori, K. (1959)
Isolation of echinochrome A from the spines of the sea urchin, *Diadema setosum* (Leske). Nature 184:1234.

Nishida, M. and J.S. Lucas (1988)
Genetic differences between geographic populations of the crown-of-thorns starfish throughout the Pacific region. Marine Biology 98:359-368.

Nishihira, M. and K. Yamazato (1972)
Brief survey of *Acanthaster planci* in Sesoko Island and its vicinity, Okinawa. Sesoko Mar. Sci. Lab. Tech. Rep. 1:1-20.

Okaji, K. (1989)
Delayed spawning activity and prolonged reproductive period in dispersed individuals of *Acanthaster planci* (L.) in Okinawa. MSc thesis. Dept. of Marine Sciences, University of the Ryukyus, Okinawa.

Okaji, K. (1991)
Delayed spawning activity in dispersed individuals of *Acanthaster planci* in Okinawa. In: Biology of Echinodermata. Eds. T. Yanagisawa, I. Yasumasu, C. Oguro, N. Suzuki, and T. Motokawa. Proc. 7th Int. Echinoderm Conf. Atami. Japan. p.291-296.

Ormond, R.F.G. and A.C. Campbell (1971)
Observations on *Acanthaster* and other coral reef echinoderms in the Sudanese Red Sea. Symp. Zool. Soc. Lond. 28:433-454.

Ormond, R.F.G. and A.C. Campbell (1974)
Formation and breakdown of aggregations of the *Acanthaster planci* aggregations in the Red Sea. In: Proc. 2nd Int. Symp. on Coral Reefs Vol. 1. Brisbane. GBR Committee. p.595-619.

Ormond, R.F.G., R.H. Bradbury, S. Bainbridge, K. Fabricius, J. Keesing, L.M. De Vantier, P. Medlay and A. Steven (1990)
Test of a model of regulation of crown-of-thorns starfish by fish predators. In: Bradbury, R.H., ed. *Acanthaster* and the coral reef: a theoretical perspective. (Lecture Notes in Biomathematics; 88). Berlin: Springer-Verlag. p. 189-207.

Owens, D. (1971)
Acanthaster planci starfish in Fiji: survey of incidence and biological studies. Fiji agric. J. 33:15-23.

Packard, G.C. and T.J. Boardman (1988)
The misuse of ratios, indices and percentages in ecophysiological research. Physiol. Zool. 6(1):1-9.

Paine, R.T. (1976a)
Size-limited predation: an observational and experimental approach with the *Pisaster-Mytilus* interaction Ecology 57:858-873.

Paine, R.T. (1976b)
Biological observations on a subtidal *Mytilus californianus* bed. The Veliger Vol. 19/2. p.125-130.

Parslow, J.S. (1990)
Stochastic and spatial effects in predator-prey models of *Acanthaster* - coral interactions. In: Bradbury, R.H., ed. *Acanthaster* and the coral reef: a theoretical perspective. (Lecture Notes in Biomathematics; 88). Berlin: Springer-Verlag. p. 72-94.

Partridge, L. and R. Sibly (1991)
Constraints in the evolution of life histories. Phil. Trans. R. Soc. Lond. B. 332:33-13.

Pauly, D. (1979)
Gill size and temperature as governing factors in fish growth: a generalisation of von Bertalanffy's growth formula. Ber. Inst. Meerekd. Christian-Albrechts Univ. Kiel. Vol. 63. 156pp.

Pauly, D. (1991)
Growth performance in fishes: rigorous description of patterns as a basis for understanding causal mechanisms. Aquabyte 4(3):3-6.

Pearse, J.S. and Pearse, V.B. (1975)
Growth zones in the echinoid skeleton. Am. Zool. 15:731-754.

Pearson, R.G. and R. Endean (1969)
A preliminary study of the coral predator *Acanthaster planci* (L.) (Asteroidea) on the Great Barrier Reef. Fish Notes Qld. 3:27-55.

Peters, R.H. (1983)
The ecological implications of body size. Cambridge Univ. Press. Cambridge. 329pp.

Phillipi, T. and J. Seger (1989)
Hedging one's evolutionary bets, revisited. Trends Ecol. Evol. 4:41-44.

Pianka, E.R. (1970)
On *r*- and *K*-selection. Am. Nat. 104:592-597.

Pianka, E.R. and W.S. Parker (1975)
Age-specific reproductive tactics. Am. Nat. 109:453-463.

Policansky, D. (1983)
Size, age and demography of metamorphosis and sexual maturity in fishes. Am. Zoo. 23:57-63.

Radke, R.L. (1987)
Age and growth information available from the otoliths of the Hawaiian snapper, *Pristipomoides filamentosus*. Coral Reefs 6:19-25.

Reichelt, R.E. (1990)
Dispersal and control models of *Acanthaster planci* populations on the Great Barrier Reef. In: *Acanthaster* and the coral reef: a theoretical perspective. Ed. R.H. Bradbury. (Lecture Notes in Biomathematics; 88). Berlin: Springer-Verlag. p. 6-16.

Reichelt R.E, R.H Bradbury and P.J. Moran (1990)
Distribution of *Acanthaster planci* outbreaks on the Great Barrier Reef between 1966 and 1989. Coral Reefs 9:97-103.

Reiss, M.J. (1989)
The allometry of growth and reproduction. Cambridge University Press. Cambridge. 180pp.

Reznick, D.N. (1990)
Plasticity in age and size at maturity in male guppies (*Poecilia reticulata*): an experimental evaluation of alternative models of development. J. Evol. Biol. 3:185-203.

Ricklefs, R.E. (1981)
Fitness, reproductive value age structure, and the optimisation of life history patterns. Am. Nat. 117:819-825.

Roff, D.A. (1992)
The evolution of life histories; theory and analysis. Chapman and Hall. New York. 535pp.

Sakai, K. (1985)
Brief observations on the population of the *Acanthaster planci* (L.) and coral assemblages around Sesoko Island, Okinawa in 1983. Galaxea. 4:23-31.

Salaque, A., M. Barbier and E. Lederer (1967)
Sur la biosynthèse de l'échinochrome A par l'oursin *Arbacia pustulosa.* Bull. Soc. Chim. Biol. 49(7):841-848.

Scheibling, R.E. (1980b)
Dynamics and feeding activity of high-density aggregations of *Oreaster reticulatus* (Echinodermata: Asteroidea) in a sand patch habitat. Mar. Ecol. Prog. Ser. 2:321-327.

Scheibling, R.E. (1981a)
The annual reproductive cycle of *Oreaster reticulatus* (L.) (Echinodermata: Asteroidea) and interpopulation differences in reproductive capacity. J. Exp. Mar. Biol. Ecol. 54:39-54.

Scheibling, R.E. (1982b)
Differences in body size and growth rate between morphs of *Echinaster* (Echinodermata: Asteroidea) from the eastern Gulf of Mexico. In: Echinoderms: proceedings of the international conference, Tampa Bay. Ed. J. M. Lawrence. Balkema. Rotterdam. p.291-298.

Schaffer, W.M. (1974a)
Selection for optimal life histories. The effects of age structure. Ecology 55:291-303.

Schaffer, W.M. (1983)
The application of optimal control theory to the general life history problem. Am. Nat. 121:418-431.

Sebens, K.P. (1987)
The ecology of indeterminate growth in animals Ann. Rev. Ecol. Syst. 18:371-407.

Seber, G.A.F. (1982)
The estimation of animal abundance and related parameters. Second edition. Macmillan. New York. 506pp.

Seger, J. and H.J. Brockman (1987)
What is bet-hedging? In: Oxford surveys in evolutionary biology. Vol. 4/1. Evolution. Oxford University Press. p.182-211.

Seyle, H. (1980)
The stress concept today. In: Handbook of stress and anxiety: contemporary knowledge, theory and treatment. Eds. E.L. Kutash and L.. Schlesinger. Jossly-Bass Inc. San Francisco. p.127-143.

Seymour, R.M. and R.A. Bradbury (1994)
Spatial waves or synchronicity of outbreaks of crown-of-thorns starfish on the Great Barrier Reef?: A Bayesian message from large scale data. J. Theor. Biol. 166:463-460.

Sibly, R. and P. Calow (1983)
An integrated approach to life-cycle evolution using selective landscapes. J. theor. Biol. 102:527-547.

Sibly, R. and P. Calow (1986)
Physiological ecology of animals. Blackwell Scientific. Oxford. 179pp.

Sibly, R. and P. Calow (1987)
Growth and resource allocation. In, Evolutionary physiological ecology. Ed. P. Calow. Cambridge Univ. Press. Cambridge. p.37-52.

Sibly, R., P. Calow and N. Nichols (1985)
Are patterns of growth adaptive? J. theor. Biol. 112:553-574.

Singh, H., R.E. Moore and P.J. Scheuer (1967)
The distribution of quinone pigments in echinoderms. Experentia 23:624-626.

Smith, G.F.M. (1940)
Factors limiting distribution and size in the starfish. J. Fish. Res. Bd. Can. 5:84-103.

Smith, A.B. (1980)
Stereom microstructure of the echinoid test. Special papers in palaeontology No. 25. The Palaeontological Association, London. 81pp.

Smith R.H. (1991)
Genetic and phenotypic aspects of life history evolution in animals. Adv. in Ecol. Res. 21:63-120.

Somers, I.F. (1988)
On a seasonally oscillating growth function. Fishbyte. 6(1):8-11.

Stearns, S.C. (1976)
Life history tactics: a review of ideas. Quart. Rev. Biol. 51(1):3-47.

Stearns, S.C. (1977)
The evolution of life-history traits: a critique of the theory and a review of the data. Ann. Rev. Ecol. Syst. 8:145-171.

Stearns, S.C. (1980)
A new view of life history evolution. Oikos. 35:266-281.

Stearns, S.C. (1982)
The role of development in the evolution of life histories. In: Evolution and development. Report of the Dahlem Workshop on Evolution and Development. Berlin. May 10 - 15, 1981. Ed. J.T. Bonner. Springer-Verlag. p.237-258.

Stearns, S.C. (1984)
The tension between adaptation and constraint in the evolution of reproductive patterns. Adv. in Inv. Rep. 3. Eds. Engels, W. et al.. Elsevier Science Publishers BV. p.387-398.

Stearns, S.C. (1989b)
Trade-offs in life history evolution. Funct. Ecol. 3:259-268.

Stearns, S.C. (1992)
The evolution of life histories. Oxford Univ. Press. Oxford. 255pp.

Stearns, S.C. and J.C. Koella (1986)
The evolution of phenotypic plasticity in life-history traits: predictions of reaction norms for age and size at maturity. Evolution 40(5):893-913.

Strathmann, R.R. (1974)
The spread of sibling larvae of sedentary marine invertebrates. Am. Nat. 108:29-44.

Stump, R.J.W (1992)
Life-history characteristics of *A canthaster planci* (L.) populations potential clues to causes of outbreaks. In: The possible causes and consequences of outbreaks of the crown-of-thorns starfish. Eds. U. Engelhardt and B. Lassig. GBRMPA workshop series No. 18. p.105-116.

Stump R J W (1993)
Age and growth of *A canthaster planci* (L.) from the GBR. In, Proc. Int. Coral Reef Symp. June 1991. Guam. USA. p.804

Stump, R.J.W and J.S. Lucas (1990)
Linear growth in spines from *A canthaster planci* (L) involving growth lines and periodic pigment bands Coral Reefs 9:149-154.

Stump, R.J.W. and J.S. Lucas (1991)
Independent assessment of aged *A canthaster planci* (L.) from the GBR using spine ossicle length and estimated reproductive effort. In: Biology of Echnodermata. Eds. T. Yanagisawa, I. Yasumasu, C. Oguro, N. Suzuki, and T. Motokawa. Balkema. Rotterdam. p309.

Taki, J. (1972a)
A tetracycline labelling observation on growth zones in the test plate of *Strongylocentrotus intermedius*. Bull. Jap. Soc. Sci. Fish. V.38 No.2:117-121.

Taki, J. (1972b)
A tetracycline labelling observation on growth zones in the jaw apparatus of *Strongylocentrotus intermedius*. Bull. Jap. Soc. Sci. Fish. V.38 No.3:181-188.

Talbot, F.H. and M.S. Talbot (1971)
The crown-of-thorns starfish (*A canthaster*) on the Great Barrier Reef. Endeavour (Oxf.) 30:38-42.

Taylor, H.M., R.S. Gourley, C.E. Lawrence and R.S. Kaplan (1974)
Natural selection of life history attributes: an analytical approach. Theor. Pop. Biol. 5:104-122.

Thomassin, B.A. (1984)
The *A canthaster* infestations: a step in the damaging evolution of the coral reef ecosystem. In: Proc. 5th Int. Echin. Conf., Galway. Balkema. Rotterdam. p.598.

Timko, P.L. (1975)
High density aggregation in *Dendraster excentricus* (Escholtz): analysis of strategies and benefits concerning growth, age. PhD thesis. University of California, Los Angeles. Los Angeles. 305pp.

Vance, R.R. (1992)
Optimal somatic growth and reproduction in a limited constant environment: organisms with determinate growth. J. theor. Biol. 157:31-50.

Via, S. (1993)
Adaptive phenotypic plasticity: target or by-product of selection in a variable environment. Am. Nat. 142:352-365.

Vine, P.J. (1973)
Crown-of-thorns (*Acanthaster planci*) plagues: the natural causes theory. Atoll Res. Bull. 166:1-10.

Vøllestad, L.A., J.H. L'Abée-lund, and H. Sægrov (1993)
Dimensionless numbers and life history variation in Brown Trout. Evol. Ecol. 7:207-218.

Walbran, P. (1987)
Atlas of *Acanthaster planci* skeletal elements. GBRMPA Technical Report No. 11. 42pp.

Watanabe, M. (1983)
Acanthaster spine: its shape and response to stimulation. Galaxea. V.2 No.1:81.

Weber, J.N. (1969)
Origin of concentric banding in the spines of the tropical echinoid *Heterocentrotus*. Pac. Sci. 23:452-466.

Weeks, S.C. (1993)
Phenotypic plasticity of life-history traits in clonal and sexual fish (*Poeciliopsis*) at high and low densities. Oecologia. 93:307-314.

Williams, D.McB., Wolanski, E., and J.C. Andrews (1984)
Transport mechanisms and the potential movement of planktonic larvae in the central region of the Great Barrier Reef. Coral Reefs 3:229-236.

Williams, G.C. (1957)
Pleiotropy, natural selection and the evolution of senescence. Evolution 11:398-411.

Wilson, B.R. and L.M. Marsh (1974)
Acanthaster studies on a Western Australian coral reef. In, Proc. 2nd Int. Symp. on Coral Reefs. Eds. Cameron, A.M. et al. Vol. 1. Brisbane. p.621-630.

Yamaguchi, M. (1973)
Early life histories of coral reef asteroids with special reference to *Acanthaster planci* (L.). In: Biology and geology of coral reefs. Vol. 2. Biology 1. Eds. O.A. Jones and R. Endean. Academic Press. New York. p.369-387.

Yamaguchi, M. (1974)
Growth of juvenile *Acanthaster planci* (L) in the laboratory Pac Sci 28:123-138

Yamaguchi, M. (1975)
Estimating growth parameters from growth rate data. Problems with marine sedentary invertebrates. Oecologia 20:321-332.

Yamaguchi. M. (1986)
Acanthaster planci infestations of reefs and coral assemblages in Japan: a retrospective analysis of control efforts. Coral Reefs 5:23-30.

Yamaguchi, M. (1987)
Occurrences and persistency of *Acanthaster planci* pseudo-population in relation to oceanographic conditions along the Pacific coast of Japan. Galaxea 6:277-288.

Yokochi, H. and M. Ogura (1987)
Spawning period and discovery of juvenile *Acanthaster planci* (L.) (Echinodermata: Asteroidea) at northwestern Iriomote-jima, Ryukyu Islands. Bull. Mar. Sci. 41:611-616.

Yokochi, H., S. Ueno, M. Ogura, A. Nagai and T. Habe (1992)
Changes in diel feeding pattern with population density and food availability for *Acanthaster planci* (L.): an experimental view. Proc. 7th Int. Coral Reef Symp. Guam. USA. p.797-802.

Yonge, C.M. (1949)
The sea shore. New Naturalist Series. London. 311pp.

Zann, L., Brodie, J., Berryman, C. and M. Naqasima (1987)
Recruitment, ecology, growth and behaviour of juvenile *Acanthaster planci* (L.) (Echinodermata: Asteroidea). Bull. mar. Sci. 41:561-575.

Zann, L. and K. Weaver (1988)
An evaluation of control programs on the crown-of-thorns starfish undertaken on the Great Barrier Reef. In, Proc. 6th Int. Coral Reef Symp. Vol 2:183.

Zann, L, J Brodie and V Vuki (1990)
History and dynamics of the crown-of-thorns starfish *Acanthaster planci* (L.) in the Suva area, Fiji. Coral Reefs 9:135-144.

Zar, J.H. (1984)
Biostatistical analysis. Prentice-Hall. New Jersey. 718pp.

APPENDICES

APPENDIX 3.1

APPENDIX 3.1A. Overall linear regression relationships and ANOVA and Tukey (HSD) serial pairwise comparisons of means between cohorts using all data for morphometric characters.

$\mathbf{F}_{(ratio)}$	Tukey serial test
Whole body diameter (BD)	
(BD) = 33.663 + 0.0904 x (AGE)	
r^2 = 0.07; P < 0.01; n = 1548; MSE = 18.45	
35.93 > $\mathbf{F}_{(\alpha 2;0.01;6,1536)}$ ≈ 2.80; P< 0.01	82≈83≈84>85>86≈87>88
Mean spine ossicle length (S)	
(S) = 14.882 + 0.2534 x (AGE)	
r^2 = 0.68; P < 0.01; n = 1549; MSE = 5.51	
136.43 > $\mathbf{F}_{(\alpha 2;0.01;6,1537)}$ ≈ 2.80; P< 0.01	82≈83>84>85>86>87>88
Mean whole spine appendage length (WS)	
(WS) = 18.136 + 0.4606 x (AGE)	
r^2 = 0.72; P < 0.01; n = 1542; MSE = 14.81	
151.07 > $\mathbf{F}_{(\alpha 2;0.01;6,1530)}$ ≈ 2.80; P< 0.01	82≈83>84>85>86>87>88
Mean primary oral ossicle weight (PO)	
(PO) = 0.0357 + (8.292 x 10^{-4}) x (AGE)	
r^2 = 0.33; P < 0.01; n = 566; MSE = 2.896 x 10^{-4}	
21.57 > $\mathbf{F}_{(\alpha 2;0.01;6,555)}$ ≈ 2.80; P< 0.01	82≈83≈84>85≈86≈87≈88
Mean secondary oral ossicle weight (SO)	
(SO) = 0.0257 + (5.724 x 10^{-4}) x (AGE)	
r^2 = 0.28; P < 0.01; n = 575; MSE = 1.723 x 10^{-4}	
16.99 > $\mathbf{F}_{(\alpha 2;0.01;6,564)}$ ≈ 2.80; P< 0.01	82≈83≈84>85≈86≈87≈88

APPENDIX 3.1B. ANOVA and Tukey (HSD) serial pairwise comparisons of means between cohorts omitting data from sub adult individuals ((AGE) < 3+ year) for morphometric characters.

$\mathbf{F}_{(ratio)}$ test		Tukey serial test
(a)	Mean whole body diameter (BD)	
	$35.29 > \mathbf{F}_{(\alpha 2;0.01;5,1261)} \approx 3.02$; P< 0.01	82≈83≈84>85≈86≈87
(b)	Mean spine ossicle length (S)	
	$200.55 > \mathbf{F}_{(\alpha 2;0.01;5,1262)} \approx 3.02$; P< 0.01	82≈83>84>85>86≈87
(b)	Mean whole spine appendage length (S)	
	$220.43 > \mathbf{F}_{(\alpha 2;0.01;5,1257)} \approx 3.02$; P< 0.01	82≈83>84>85>86≈87
(c)	Mean primary oral ossicle weight (PO)	
	$31.32 > \mathbf{F}_{(\alpha 2;0.01;5,455)} \approx 3.05$; P< 0.01	82≈83≈84>85≈86≈87
(e)	Mean secondary oral ossicle weight (SO)	
	$22.13 > \mathbf{F}_{(\alpha 2;0.01;5,462)} \approx 3.05$; P< 0.01	82≈83≈84>85≈86≈87

APPENDIX 3.2

APPENDIX 3.2A. ANOVA and Tukey (HSD) serial pairwise comparisons of mean whole body diameter (BD) between sampling dates using all data for morphometric characters in each cohort (as estimated by (AGE)).

(BD) cm

Replication Test of Fit (RTOF)

Cohort year	$F_{(ratio)}$ (RTOF analysis)	Regression analysis
82	NS; $P = 0.63$; $P^{(B)} = 0.74$	$r^2 = 0.06$; $P = 0.24$; $n = 24$; $MSE = 9.88$
83	NS; $P = 0.56$; $P^{(B)} = 0.08$	$r^2 = 0.02$; $P = 0.24$; $n = 63$; $MSE = 17.73$
84	NS; $P = 0.03$; $P^{(B)} < 0.01$	$r^2 = 0.01$; $P = 0.20$; $n = 131$; $MSE = 17.88$
85	NS; $P < 0.01$; $P^{(B)} < 0.01$	$r^2 < 0.01$; $P = 0.55$; $n = 691$; $MSE = 17.45$
86	NS; $P < 0.01$; $P^{(B)} < 0.01$	$r^2 = 0.01$; $P = 0.02$; $n = 508$; $MSE = 16.03$
87	NS; $P < 0.01$; $P^{(B)} = 0.41$	$r^2 = 0.01$; $P = 0.47$; $n = 72$; $MSE = 19.60$
88	NS; $P = 0.05$; $P^{(B)} = 0.25$	$r^2 = 0.40$; $P = 0.01$; $n = 15$; $MSE = 25.09$

APPENDIX 3.2B

Curve fit test for asymptotic growth (von Bertalanffy growth equation) and seasonal oscillation in whole body diameter (BD) within cohorts over the study period.

using (a) seasonal $y = a + (b \cdot \cos((x - c) \cdot 0.524)) + (d \cdot x)$
(b) asymptotic $y = l \cdot (1 - (m \cdot e^{(-k \cdot x)}))$
(c) (a) & (b) $y = b \cdot (\cos(x - c) \cdot 0.524)) + (l \cdot (1 - (m \cdot e^{(-k \cdot x)}))$

82 cohort using equation (a)

Parameters	SE	$t_{(0.01(1)20)}=2.53$	P
a = 41.48	1.181	35.12	< 0.01
b = 2.07	2.179	0.95	> 0.25
c = 8.87	1.00	8.87	< 0.01
d = 0.131	.0824	1.59	> 0.1

Analysis of curve model significance

Curve parameters are not significant

83 cohort using equation (a)

Parameters	SE	$t_{(0.01(1)59)}=2.39$	P
a = 43.91	0.947	46.37	< 0.01
b = 0.753	0.675	1.12	> 0.1
c = 25.1	4.367	5.75	< 0.01
d = -0.054	0.050	1.08	> 0.1

Analysis of curve model significance

Curve parameters are not significant

84 cohort using equation (a)

Parameters	SE	$t_{(0.01(1)130)}=2.36$	P
a = 40.06	0.645	62.07	< 0.01
b = 1.319	0.5104	2.58	< 0.01
c = 25.49	1.30	19.61	< 0.01
d = -0.054	0.034	1.47	> 0.05

reanalyse without the slope parameter

Parameters	SE	$t_{(0.01(1)131)}=2.35$	P
a = 40.81	0.397	102.8	< 0.01
b = 1.456	0.667	2.18	< 0.01
c = 25.97	0.990	26.22	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	152.1	2	76.04	4.45	< 0.02
	Error	2238	131	17.08		
	Total	2390	133			

Analysis of curve model significance

$$MSE_{(regression)} = 17.88 > MSE_{(curve)} = 17.08;\ r^2 = 0.06.$$

Curve analysis is weakly significant, linear regression analysis is preferred.

85 cohort using equation (a)

Parameters	SE	$t_{(0.01(1)130)}=2.36$	P
a = 38.95	0.30	129.9	< 0.01
b = 1.358	0.1869	7.27	< 0.01
c = 24.77	0.606	40.89	< 0.01
d = 0.0074	0.0165	0.45	> 0.25

reanalyse without the slope parameter

Parameters	SE	$t_{(0.01(1)704)}=2.35$	P
a = 39.06	0.190	205.8	< 0.01
b = 1.361	0.194	7.03	< 0.01
c = 24.85	0.568	43.77	< 0.01

Curve fit	SS	DF	MS	F	P
Curve	960.6	2	480.3	29.81	< 0.01
Error	11340	704	16.11		
Total	12301	706			

Analysis of curve model significance

$MSE_{(regression)} = 17.45 < MSE_{(curve)} = 16.11$; $r^2 = 0.08$; curve analysis is preferred.

86 cohort using equation (c)

Parameters	SE	$t_{(0.01(1)521)}=2.33$	P
b = 0.967	0.219	4.53	< 0.01
c = 24.92	0.795	31.34	< 0.01
l = 38.84	0.257	151.3	< 0.01
m = 0.181	0.0284	6.38	< 0.01
k = -0.230	0.0792	2.90	< 0.01

Curve fit	SS	DF	MS	F	P
Curve	855.6	4	213.4	14.61	< 0.01
Error	7597	519	14.64		
Total	8453	524			

Analysis of curve model significance

$MSE_{(regression)} = 16.03 > MSE_{(curve)} = 14.64$; $r^2 = 0.10$; curve analysis is preferred.

87 cohort using equation (b)

Parameters	SE	$t_{(0.01(1)70)}=2.38$	P
l = 36.99	0.51	72.06	< 0.01
m = 42.94	1515	0.03	> 0.25
k = -0.740	5.33	0.14	> 0.25

Analysis of curve model significance

Curve parameters are not significant

88 cohort using equation (b)

Parameters	SE	$t_{(0.01(1)12)}=2.68$	P
l = 33.73	3.428	9.84	< 0.01
m = 25.85	109.1	0.24	> 0.25
k = 0.256	0.323	0.79	> 0.25

Analysis of curve model significance

Curve parameters are not significant

APPENDIX 3.3

APPENDIX 3.3A. ANOVA and Tukey (HSD) serial pairwise comparisons of spine ossicle length (S) between sampling dates using all data for morphometric characters in each cohort (as estimated by (AGE)). $P_{(B)}$ = Bartlett's test of equal variances.

(S) mm

Replication Test of Fit (RTOF)

Cohort	$F_{(ratio)}$ (RTOF analysis)	Regression analysis
82	$0.52 < F_{(\alpha1;0.01;4;4,18)} = 4.58$ $P > 0.25$; $P_{(B)}=0.54$	$r^2 = 0.63$; $P < 0.01$; $n = 24$; MSE =5.66
83	$3.00 < F_{(\alpha1;0.01;6,55)} \approx 3.12$ $P < 0.02$; $P_{(B)} = 0.27$	$r^2 = 0.46$; $P < 0.01$; $n = 63$; MSE = 5.32
84	$1.53 < F_{(\alpha1;0.01;6,126)} \approx 2.93$ $P > 0.10$; $P_{(B)} = 0.11$	$r^2 = 0.59$; $P < 0.01$; $n = 134$; MSE = 6.08
85	$9.65 > F_{(\alpha1;0.01;6,700)} \approx 2.80$ $P < 0.01$; $P_{(B)} = 0.37$	$r^2 = 0.56$; $P < 0.01$; $n = 708$; MSE = 5.39
86	$19.7 > F_{(\alpha1;0.01;6,516)} \approx 2.80$ $P < 0.01$; $P_{(B)} = 0.01$	$r^2 = 0.54$; $P < 0.01$; $n = 524$; MSE = 4.82
87	$2.63 < F_{(\alpha1;0.01;5,65)} \approx 3.29$ $P < 0.05$; $P_{(B)} = 0.55$	$r^2 = 0.37$; $P < 0.01$; $n = 72$; MSE = 4.29
88	$3.03 < F_{(\alpha1;0.01;2,11)} = 7.21$ $P < 0.10$; $P_{(B)} = 0.39$	$r^2 = 0.72$; $P < 0.01$; $n = 15$; MSE = 4.57

APPENDIX 3.3B

Curve fit test for asymptotic growth (von Bertalanffy growth equation) and seasonal oscillation in spine ossicle length (S) within cohorts over the study period.

using (a) seasonal $y = a + (b \,.\, \cos((x - c) \,.\, 0.524)) + (d \,.\, x)$
(b) asymptotic $y = l \,.\, (1 - (m \,.\, e^{(-k \,.\, x)}))$
(c) (a) & (b) $y = b \,.\, (\cos(x - c) \,.\, 0.524)) + (l \,.\, (1 - (m. \; e^{(-k \,.\, x)}))$

82 cohort using equation (b)

Parameters	SE	$t_{(0.01(1)20)}=2.53$	P
l = 45.39	9.874	4.60	< 0.01
m = 0.261	0.150	1.75	< 0.05
k = 0.0394	0.0608	0.65	> 0.25

Analysis of curve model significance

Curve parameters are not significant.

83 cohort using equation (b)

Parameters	SE	$t_{(0.01(1)60)}=2.39$	P
l = 40.67	1.597	25.47	< 0.01
m = 0.198	0.0289	6.84	< 0.01
k = 0.0601	0.0277	2.19	< 0.02

Curve fit		SS	DF	MS	F	P
(a)	Curve	311.1	2	155.6	32.06	< 0.01
	Error	291.2	60	4.853		
	Total	602.3	62			

Analysis of curve model significance

$MSE_{(regression)} = 5.32 > MSE_{(curve)} = 4.85$; $r^2 = 0.52$; curve parameter is weakly significant, linear regression analysis is preferred

84 cohort using equation (b)

Parameters	SE	$t_{(0.01(1)131)}=2.35$	P
l = 40.83	2.345	17.41	< 0.01
m = 0.299	0.0362	8.25	< 0.01
k = 0.0419	0.0153	2.74	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	1183	2	591.3	102.9	< 0.01
	Error	752.7	131	5.746		
	Total	1936	133			

Analysis of curve model significance

$MSE_{(regression)} = 6.08 > MSE_{(curve)} = 5.75$; $r^2 = 0.61$. Curve parameter is significant, curve analysis is preferred.

85 cohort using equation (b)

(i) Select all data

Parameters	SE	$t_{(0.01(1)705)}\approx 2.33$	P
l = 50.0	6.475	7.70	< 0.01
m = 0.490	0.0707	6.93	< 0.01
k = 0.0132	0.0059	2.26	< 0.02

Curve fit		SS	DF	MS	F	P
	Curve	4729	2	2365	431.2	< 0.01
	Error	3866	705	5.483		
	Total	8595	707			

Analysis of curve model significance

Curve parameter is weakly significant, use linear regression analyses.

(ii) Omit samples > 18 months

Parameters	SE	$t_{(0.01(1)509)} \approx 2.33$	P
l = 30.0	0.307	97.63	< 0.01
m = 0.156	0.0106	14.79	< 0.01
k = 0.173	0.044	3.95	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	1090	2	545	111.3	< 0.01
	Error	2492	509	4.897		
	Total	3582	511			

Analysis of curve model significance

$MSE_{(regression)} = 5.11 > MSE_{(curve)} = 4.90$; $r^2 = 0.30$. Curve parameters are significant, curve analysis is preferred.

Therefore asymptotic curve fitted from months t_0 to 18 in the 1985 cohort.

86 cohort using equation (b)

(i) Select all data

Parameters	SE	$t_{(0.01(1)523)} \approx 2.33$	P
l = 41.53	3.678	11.29	< 0.01
m = 0.466	0.0405	11.51	< 0.01
k = 0.0225	0.0067	3.33	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	3067	2	1533	322.6	< 0.01
	Error	2486	523	4.754		
	Total	5553	525			

Analysis of curve model significance

$MSE_{(regression)} = 4.82 \approx MSE_{(curve)} = 4.75$; $r^2 = 0.55$. MSE is lowered by only 0.07, linear regression analysis is preferred.

(ii) Omit samples > 26 months (see Figure 3.12)

Parameters	SE	$t_{(0.01(1)376)} \approx 2.43$	P
l = 29.11	0.301	96.81	< 0.01
m = 0.293	0.017	17.17	< 0.01
k = 0.140	0.021	6.82	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	1011	2	505.4	136.4	< 0.01
	Error	1393	376	3.706		
	Total	2404	378			

Analysis of curve model significance

$MSE_{(regression)} = 4.50 > MSE_{(curve)} = 3.71$; $r^2 = 0.39$. Curve analysis is preferred.

Therefore asymptotic curve fitted from months t_0 to 25mo. in the 1985 cohort.

87 cohort using equation (b)

(i) Select all data

Parameters	SE	$t_{(0.01(1)71)} \approx 2.38$	P
l = 32.89	4.532	7.26	< 0.01
m = 0.387	0.0483	8.01	< 0.01
k = 0.0367	0.0330	1.13	> 0.10

Analysis of curve model significance

Curve parameter is not significant.

(ii) Omit samples > 24 months

Parameters	SE	$t_{(0.01(1)38)} \approx 2.43$	P
l = 26.41	0.407	64.89	< 0.01
m = 7.903	119.9	0.66	> 0.25
k = 0.567	2.266	0.25	> 0.25

Analysis of curve model significance

Curve parameters are not significant.

88 cohort

Parameters	SE	$t_{(0.01(1)12)} \approx 2.68$	P
l = 40.0	48.7	0.82	> 0.25
m = 1.009	0.6431	1.57	< 0.10
k = 0.033	0.088	0.37	> 0.25

Analysis of curve model significance

Curve parameters are not significant.

APPENDIX 3.4

APPENDIX 3.4A. ANOVA and Tukey (HSD) serial pairwise comparisons of mean whole spine appendage length (WS) between sampling dates using all data for morphometric characters in each cohort (as estimated by (AGE)). $P_{(B)}$ = Bartlett's test of equal variances.

(WS) mm

Replication Test of Fit (RTOF)

Cohort	$F_{(ratio)}$ (RTOF)	Regression analysis
82	$0.78 < F_{(\alpha1;0.01;4;4,18)} = 4.58$ $P > 0.25$; $P_{(B)}=0.54$	$r^2 = 0.49$; $P < 0.01$; n = 24; MSE 23.19
83	$2.58 < F_{(\alpha1;0.01;6,55)} \approx 3.12$ $P < 0.05$; $P_{(B)} = 0.98$	$r^2 = 0.47$; $P < 0.01$; n = 63; MSE 19.77
84	$1.63 < F_{(\alpha1;0.01;6,126)} \approx 2.93$ $P > 0.10$; $P_{(B)} = 0.42$	$r^2 = 0.67$; $P < 0.01$; n = 134; MSE 14.86
85	$7.79 > F_{(\alpha1;0.01;6,700)} \approx 2.80$ $P < 0.01$; $P_{(B)} = 0.03$	$r^2 = 0.61$; $P < 0.01$; n = 708; MSE 14.02
86	$16.04 > F_{(\alpha1;0.01;6,516)} \approx 2.80$ $P < 0.01$; $P_{(B)} = 0.01$	$r^2 = 0.54$; $P < 0.01$; n = 524; MSE 12.71
87	$2.73 < F_{(\alpha1;0.01;5,65)} \approx 3.29$ $P < 0.05$; $P_{(B)} = 0.73$	$r^2 = 0.48$; $P < 0.01$; n = 72; MSE 10.69
88	$3.07 < F_{(\alpha1;0.01;2,11)} = 7.21$ $P < 0.10$; $P_{(B)} = 0.61$	$r^2 = 0.76$; $P < 0.01$; n = 15; MSE 10.05

APPENDIX 3.4B

Curve fit test for asymptotic growth (von Bertalanffy growth equation) and seasonal oscillation in whole spine appendage length (S) within cohorts over the study period.

using (a) seasonal $y = a + (b \,.\, \cos((x - c) \,.\, 0.524)) + (d \,.\, x)$
(b) asymptotic $y = l \,.\, (1 - (m \,.\, e^{(-k \,.\, x)}))$
(c) (a) & (b) $y = b \,.\, (\cos(x - c) \,.\, 0.524)) + (l \,.\, (1 - (m \,.\, e^{(-k \,.\, x)}))$

82 cohort using equation (b)

Parameters	SE	$t_{(0.01(1)21)} \approx 2.52$	P
l = 80.61	5.964	1.35	> 0.10
m = 0.332	0.515	0.64	> 0.25
k = 0.0200	0.0833	0.24	> 0.25

Analysis of curve model significance

Curve parameters are not significant.

83 cohort using equation (b)

Parameters	SE	$t_{(0.01(1)60)}=2.39$	P
l = 63.33	1.471	43.05	< 0.01
m = 0.240	0.0244	9.85	< 0.01
k = 0.0963	0.0285	3.38	< 0.01

Curve fit		SS	DF	MS	F	P
(a)	Curve	1318	2	659.2	41.4	< 0.01
	Error	955.2	60	15.92		
	Total	2274	62			

Analysis of curve model significance

$MSE_{(regression)} = 23.19 > MSE_{(curve)} = 15.92$; $r^2 = 0.52$. Curve analysis is preferred.

84 cohort using equation (b)

Parameters	SE	$t_{(0.01(1)130)}=2.36$	P
l = 70.18	6.472	10.84	< 0.01
m = 0.383	0.0524	7.32	< 0.01
k = 0.0308	0.0125	2.47	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	4104	2	2052	143.7	< 0.01
	Error	1856	130	14.28		
	Total	5960	132			

Analysis of curve model significance

$MSE_{(regression)} = 19.77 > MSE_{(curve)} = 14.28$; $r^2 = 0.61$. Curve analysis is preferred.

85 cohort using equation (b)

(i) Select all data

Parameters	SE	$t_{(0.01(1)701)} \approx 2.33$	P
l = 97.94	23.10	4.24	< 0.01
m = 0.615	0.0987	6.23	< 0.01
k = 0.00919	0.00513	1.79	< 0.05

Curve fit		SS	DF	MS	F	P
	Curve	15430	2	7717	539.8	< 0.01
	Error	10020	701	14.3		
	Total	25450	703			

Analysis of curve model significance

Curve parameter is weakly significant, use linear regression analyses.

(ii) Omit samples > 18 months

Parameters	SE	$t_{(0.01(1)509)} \approx 2.33$	P
l = 45.75	0.626	73.05	< 0.01
m = 0.175	0.0123	14.31	< 0.01
k = 0.149	0.038	3.89	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	3020	2	1510	118.5	< 0.01
	Error	6447	506	12.74		
	Total	9467	508			

Analysis of curve model significance

$MSE_{(regression)} = 13.22 > MSE_{(curve)} = 12.74$; $r^2 = 0.33$. Curve analysis is preferred.

Therefore asymptotic curve fitted from months t_0 to 18.

86 cohort

(i) Select all data

Parameters	SE	$t_{(0.01(1)523)} \approx 2.33$	P
l = 77.52	13.63	5.69	< 0.01
m = 0.584	0.0676	8.64	< 0.01
k = 0.0150	0.00632	2.37	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	9944	2	4972	395.1	< 0.01
	Error	6556	521	12.58		
	Total	16500	523			

Analysis of curve model significance

$MSE_{(regression)} = 12.71 > MSE_{(curve)} = 12.58$; $r^2 = 0.61$. MSE is lowered by only 0.13 by using the curve analysis, linear regression analysis is preferred.

(ii) Omit samples > 24 months (see Figure 3.12)

Parameters	SE	$t_{(0.01(1)375)} \approx 2.43$	P
l = 44.42	0.608	73.11	< 0.01
m = 0.336	0.018	18.45	< 0.01
k = 0.123	0.017	7.01	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	3046	2	1523	150.7	< 0.01
	Error	3790	375	10.11		
	Total	6835	377			

Analysis of curve model significance

$MSE_{(regression)} = 11.92 > MSE_{(curve)} = 10.11$; $r^2 = 0.45$. Curve analysis is preferred.

87 cohort

(i) Select all data

Parameters	SE	$t_{(0.01(1)71)} \approx 2.38$	P
l = 53.51	10.92	4.90	< 0.01
m = 0.485	0.0521	9.29	< 0.01
k = 0.0308	0.0278	1.11	> 0.10

Analysis of curve model significance

Curve parameter is not significant.

(ii) Omit samples > 24 months (see Figure 3.12)

Parameters	SE	$t_{(0.01(1)38)} \approx 2.43$	P
l = 39.13	0.997	39.25	< 0.01
m = 1.792	4.58	0.39	> 0.25
k = 0.310	0.346	0.89	> 0.25

Analysis of curve model significance

Curve parameters are not significant.

88 cohort

Parameters	SE	$t_{(0.01(1)12)} \approx 2.68$	P
l = 75.0	158.9	0.47	> 0.25
m = 1.006	0.4305	2.34	< 0.10
k = 0.022	0.080	0.28	> 0.25

Analysis of curve model significance

Curve parameters are not significant, use linear regression analyses.

APPENDIX 3.5

APPENDIX 3.5A. ANOVA and Tukey (HSD) serial pairwise comparisons of primary oral ossicle (PO) between sampling dates using all data for morphometric characters in each cohort (as estimated by (AGE)). Where; NS = not significant, $P_{(B)}$ = Bartlett's test of equal variances among groups, NT not tested, insufficient data.

(PO) g

Replication Test of Fit (RTOF)

Cohort	$F_{(ratio)}$ (RTOF)	Regression analysis
82	NS; P = 0.79 $P_{(B)}$= 0.24	r^2 = 0.12; P = 0.35; n = 9; MSE = 1.925×10^{-4}
83	NS; P = 0.17 $P_{(B)}$ = 0.98	r^2 = 0.14; P = 0.05; n = 28; MSE = 3.892×10^{-4}
84	$2.19 < F_{(\alpha 1;0.01;5,35)} = 3.59$ P < 0.10; $P_{(B)}$ = 0.95	r^2 = 0.28; P < 0.01; n = 42; MSE = 4.710×10^{-4}
85	$1.90 < F_{(\alpha 1;0.01;5,230)} \approx 3.08$ P < 0.10; $P_{(B)}$ = 0.63	r^2 = 0.29; P < 0.01; n = 237; MSE = 1.803×10^{-4}
86	$3.04 < F_{(\alpha 1;0.01;5,193)} \approx 3.11$ P < 0.02; $P_{(B)}$ = 0.18	r^2 = 0.30; P < 0.01; n = 200; MSE = 2.692×10^{-4}
87	Regression NS $P_{(AOV)}$ < 0.01; $P_{(B)}$ = 0.56	r^2 = 0.03; P = 0.31; n = 39; MSE = 4.66×10^{-4}

APPENDIX 3.5B. Curve analyses

Curve fit test for asymptotic growth (von Bertalanffy growth equation) and seasonal oscillation in primary oral ossicle weight (PO) within cohorts over the study period.

using (a) seasonal $y = a + (b \cdot \cos((x - c) : 0.524)) + (d \cdot x)$
(b) asymptotic $y = 1 \cdot (1 - (m \cdot e^{(-k \cdot x)}))$
(c) (a) & (b) $y = b \cdot (\cos(x - c) \cdot 0.524)) + (1 \cdot (1 - (m \cdot e^{(-k \cdot x)}))$

82 cohort

Not tested, sample size too small (n = 9)

83 cohort; using equation (a)

Parameters	SE	$t_{(0.01(1)25)}$=2.49	P
a = 0.1021	0.0069	14.84	< 0.01
b = -0.0125	0.0167	0.75	> 0.1
c = 33.6	0.7093	47.40	< 0.01
d = 0.0005	0.00043	1.18	> 0.1

Analysis of curve model significance

Curve parameters are not significant

84 cohort; using equation (a)

Parameters	SE	$t_{(0.01(1)39)}=2.43$	P
a = 0.0852	0.0059	14.54	< 0.01
b = 0.0043	0.0040	1.07	> 0.10
c = 30.44	4.826	6.31	< 0.01
d = 0.00104	0.00028	3.70	< 0.01

Analysis of curve model significance

Curve parameters are not significant, use linear regression

85 cohort using equation (a)

Parameters	SE	$t_{(0.01(1)130)}=2.36$	P
a = 0.0702	0.0017	42.62	< 0.01
b = 0.00064	0.0024	0.26	> 0.10
c = 22.11	6.49	3.41	< 0.01
d = 0.00072	0.00008	8.97	< 0.01

Seasonal variation parameter not significant reanalyse using equation (b).

Parameters	SE	$t_{(0.01(1)234)}=2.34$	P
l = 0.0997	0.00585	17.03	< 0.01
m = 0.3416	0.0364	9.38	< 0.01
k = 0.00495	0.0180	2.75	< 0.01

Curve fit	SS	DF	MS	F	P
Curve	0.0184	2	0.00937	53.72	< 0.01
Error	0.0408	234	0.000175		
Total	0.0596	236			

Analysis of curve model significance

$MSE_{(regression)} = 1.925x10^{-4} > MSE_{(curve)} = 1.750x10^{-4}$; $r^2 = 0.32$. Curve analysis is preferred.

86 cohort; using equation (c)

Parameters	SE	$t_{(0.01(1)198)}=2.35$	P
a = 0.0609	0.00307	19.86	< 0.01
b = 0.00602	0.00236	2.55	< 0.01
c = 28.86	0.6088	4.74	< 0.01
g = 0.00108	0.00012	9.01	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	0.02558	3	0.00853	33.39	< 0.01
	Error	0.05055	198	0.000255		
	Total	0.07613	201			

Analysis of curve model significance

$MSE_{(regression)} = 3.892 \times 10^{-4} > MSE_{(curve)} = 2.550 \times 10^{-4}$; $r^2 = 0.34$. Curve analysis is preferred.

Curve with significant seasonal variation fitted

87 cohort

Parameters	SE	$t_{(0.01(1)70)}=2.38$	P
l = 36.99	0.51	72.06	< 0.01
m = 42.94	1515	0.03	> 0.25
k = -0.740	5.33	0.14	> 0.25

Curve fit		SS	DF	MS	F	P
	Curve	267	2	133.7	8.43	< 0.01
	Error	1126	71	15.86		
	Total	1393	73			

Analysis of curve model significance

Curve parameters are not significant

88 cohort using equation (b)

Parameters	SE	t(0.01(1)12)=2.68	P
l = 33.73	3.428	9.84	< 0.01
m = 25.85	109.1	0.24	> 0.25
k = 0.256	0.323	0.79	> 0.25

Curve fit		SS	DF	MS	F	P
	Curve	270.1	2	135.1	5.91	< 0.01
	Error	274.3	12	22.86		
	Total	544.4	14			

Analysis of curve model significance

Curve parameters are not significant

APPENDIX 3.6.

APPENDIX 3.6A. ANOVA and Tukey (HSD) serial pairwise comparisons of secondary oral ossicle (SO) between sampling dates using all data for morphometric characters in each cohort (as estimated by (AGE)). Where; NS = not significant, $P_{(B)}$ = Bartlett's test of equal variances among groups.

(SO) g

Replication Test of Fit (RTOF)

Cohort	$F_{(ratio)}$ (RTOF)	Regression analysis
82	NS; P =0.79 $P_{(B)}$=0.24	$r^2 = 0.12$; P = 0.35; n = 9; MSE = 1.197×10^{-4}
83	NS; P = 0.17 $P_{(B)} = 0.98$	$r^2 = 0.14$; P = 0.05; n = 28; MSE = 2.516×10^{-4}
84	$2.19 < F_{(\alpha1;0.01;5,35)} = 3.59$ $P < 0.10$; $P_{(B)} = 0.95$	$r^2 = 0.28$; P < 0.01; n = 42; MSE = 2.483×10^{-4}
85	$1.90 < F_{(\alpha1;0.01;5,230)} \approx 3.08$ $P < 0.10$; $P_{(B)} = 0.63$	$r^2 = 0.29$; P < 0.01; n = 237; MSE = 1.276×10^{-4}
86	$3.04 < F_{(\alpha1;0.01;5,193)} \approx 3.11$ $P < 0.02$; $P_{(B)} = 0.18$	$r^2 = 0.30$; P < 0.01; n = 200; MSE = 1.590×10^{-4}
87	Only regression NS $P_{(AOV)} < 0.01$; $P_{(B)} = 0.56$	$r^2 = 0.03$; P = 0.31; n = 39; MSE = 1.914×10^{-4}

APPENDIX 3.6B

Curve fit test for asymptotic growth (von Bertalanffy growth equation) and seasonal oscillation in secondary oral ossicle weight (SO) within cohorts over the study period.

using (a) seasonal $y = a + (b \cdot \cos((x - c) \cdot 0.524)) + (d \cdot x)$
(b) asymptotic $y = l \cdot (1 - (m \cdot e^{(-k \cdot x)}))$
(c) (a) & (b) $y = b \cdot (\cos(x - c) \cdot 0.524)) + (l \cdot (1 - (m \cdot e^{(-k \cdot x)}))$

Curve fit test for asymptotic growth in mean spine ossicle length (BD) from cohorts over the study period.

82 cohort

Not tested, sample too small (n = 9)

83 cohort using equation (a)

Parameters	SE	$t_{(0.01(1)7)}=3.00$	P
a = 0.0740	0.00535	13.83	P < 0.01
b = 0.00001	0.00690	0.002	P > 0.25
c = 19.22	0.0229	0.84	P > 0.25
g = 0.000373	0.00034	1.10	P > 0.10

Analysis of curve model significance

Curve parameters not significant.

84 cohort using equation (a)

Parameters	SE	$t_{(0.01(1)40)}=2.42$	P
a = 0.0579	0.00435	13.32	< 0.01
b = 0.00474	0.00732	0.65	> 0.25
c = 22.59	1.779	12.70	< 0.01
g = 0.000785	0.00020	3.84	< 0.01

Curve parameters not significant

Refit curve using equation (b)

Parameters	SE	$t_{(0.01(1)40)}=2.42$	P
l = 0.00833	0.00523	15.95	< 0.01
m = 0.4421	0.07846	5.64	< 0.01
k = 0.1045	0.05487	1.90	< 0.05

Curve fit		SS	DF	MS	F	P
(a)	Curve	0.00566	2	0.00283	12.8	< 0.01
	Error	0.00885	40	0.000221		
	Total	0.01451	42			

Analysis of curve model significance

$MSE_{(regression)} = 2.516x10^{-4} > MSE_{(curve)} = 2.210x10^{-4}$; $r^2 = 0.39$. Curve analysis is preferred.

85 cohort

Parameters	SE	$t_{(0.01(1)236)}=2.34$	P
a = 0.0491	0.00137	35.87	< 0.01
b = 0.00223	0.00214	1.05	> 0.10
c = 33.5	0.7370	45.46	< 0.01
g = 0.000511	0.000067	7.69	< 0.01

Curve parameters not significant

Parameters	SE	$t_{(0.01(1)237)}=2.34$	P
l = 0.0679	0.00280	24.29	< 0.01
m = 0.3457	0.03255	10.62	< 0.01
k = -0.0696	0.02159	3.22	< 0.01

Curve fit		SS	DF	MS	F	P
	Curve	0.01133	2	0.00566	46.62	< 0.01
	Error	0.02879	237	0.000122		
	Total	0.04012	239			

Analysis of curve model significance

$MSE_{(regression)} = 1.276 \times 10^{-4} > MSE_{(curve)} = 1.215 \times 10^{-4}$; $r^2 = 0.28$. Curve analysis is preferred.

86 cohort; using equation (a).

Parameters	SE	$t_{(0.01(1)202)}=2.34$	P
a = 0.0431	0.00226	19.05	< 0.01
b = 0.00656	0.00191	3.43	< 0.01
c = 16.49	0.3556	46.37	< 0.01
g = 0.000712	0.000089	8.03	< 0.01

Refit curve with equation (c)

Parameters	SE	$t_{(0.01(1)202)}=2.34$	P
l = 0.0750	0.0129	5.81	< 0.01
b = 0.00689	0.00203	3.40	< 0.01
c = 40.0	0.2754	145.2	< 0.01
m = 0.5281	0.05938	8.89	< 0.01
k = -0.04265	0.01963	2.17	< 0.02

Curve fit		SS	DF	MS	F	P
	Curve	0.0132	4	0.00330	22.7	< 0.01
	Error	0.02924	201	0.000146		
	Total	0.04244	205			

Analysis of curve model significance

$MSE_{(regression)} = 1.590 \times 10^{-4} > MSE_{(curve)} = 1.455 \times 10^{-4}$; $r^2 = 0.31$. Curve analysis is preferred.

87 cohort; using equation (a)

Parameters	SE	$t_{(0.01(1)36)}=2.43$	P
a = 0.0580	0.00105	5.52	< 0.01
b = 0.00481	0.00342	1.40	< 0.10
c = 19.68	2.284	8.62	< 0.01
g = 0.000022	0.000326	0.07	> 0.25

Analysis of curve model significance

Curve parameters not significant.

88 cohort

Not tested, sample size too small

APPENDIX 3.7. Estimation of life history parameters from von Bertalanffy growth curve analyses in the four principal *A. planci* cohorts (which settled between 1983 and 1986) on Davies Reef.

APPENDIX 3.7A

Analyses of whole body diameter growth and estimated age for estimation of life history coefficients using the von Bertalanffy equation in the form:

$$L_t = L_\infty \times (1 - e^{(-K(t-t_0))})$$

where L_t = whole body diameter (cm) at age (t) (month)
L_∞ = asymptotic whole body diameter (cm)
K = growth constant ($month^{-1}$)
t_0 = correction factor for the early phase of slow growth, a preliminary plot of growth data showed that $t_0 \approx$ 10mo. and this value was used consistently through the analyses.

83 cohort

Curve fit procedure was not successful, therefore the K parameter was estimated by prior estimation of L_∞ and holding its value as constant. The analyses of variance for the curve fit estimates was therefore not applicable.

Parameters	SE	$t_{(0.01(1)61)} \approx 2.66$	P
$L_\infty = 44.04$	0.5542	79.47	< 0.01
$K = 0.0542$	0.00830	6.53	< 0.01

Analysis of curve model significance

N/A

84 cohort

Parameters	SE	$t_{(0.01(1)130)} = 2.61$	P
$L_\infty = 41.91$	0.8325	50.34	< 0.01
$K = 0.0641$	0.0148	4.33	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	42.23	1	42.23	2.374	< 0.01
	Error	2348	132	17.78		
	Total	2390	133			

$MSE_{(curve)} = 17.78$; $r^2 = 0.02$.

85 cohort

(i)

Parameters	SE	$t_{(0.01(1)705)} \approx 2.58$	P
$L_\infty = 39.50$	0.2410	163.9	< 0.01
$K = 0.1154$	0.0261	4.42	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	29.45	1	29.45	1.691	0.25 > P > 0.10
	Error	12280	705	17.41		
	Total	12300	706			

$MSE_{(curve)} = 17.41$; $r^2 = 0.002$.

(ii)

Curve fit procedure repeated using the equation for asymptotic growth and seasonal-oscillation in body size.

$$y = b \times (\cos(x - c) \times 0.524) + (L_\infty . (1 - (e^{-K(t-to)}))$$

where b = amplitude of seasonal oscillation
c = seasonal offset (months) of maxima or minima from January, each year.

Parameters	SE	$t_{(0.01(1)705)} \approx 2.58$	P
$L_\infty = 39.51$	1.190	33.20	< 0.01
$K = 0.08873$	0.0187	4.75	< 0.01
b = 2.020	0.4997	4.04	< 0.01
c = 9.111	1.2890	7.07	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	373.2	3	124.4	7.329	< 0.01
	Error	11930	703	16.97		
	Total	12300	706			

$MSE_{(curve)} = 16.97$; $r^2 = 0.03$.

86 cohort

Parameters	SE	$t_{(0.01(1)510)} \approx 2.58$	P
$L_\infty = 39.24$	0.3234	121.34	< 0.01
$K = 0.0958$	0.00935	10.25	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	354.1	1	354.1	22.84	< 0.01
	Error	8125	524	15.51		
	Total	8479	525			

$MSE_{(curve)} = 15.51$; $r^2 = 0.04$.

APPENDIX 3.7B

Analyses of spine ossicle growth and estimated age for estimation of life history coefficients using the von Bertalanffy equation in the form:

$$\mathbf{L_t} = \mathbf{L_\infty} \times (1 - e^{(-K(t-to)}$$

where $\mathbf{L_t}$ = spine ossicle length (mm) at age (t) (month)
$\mathbf{L_\infty}$ = asymptotic spine ossicle length (mm)
K = growth constant ($month^{-1}$)
t_0 = correction factor for the early phase of slow growth, a preliminary plot of growth data showed that $t_0 \approx$ 10mo. and this value was used consistently through the analyses.

83 cohort

Parameters	SE	$t_{(0.01(1)61)} \approx 2.66$	P
$L_\infty = 46.39$	2.431	19.08	< 0.01
$K = 0.0213$	0.00278	7.66	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	299.4	1	299.4	60.3	< 0.01
	Error	302.9	61	4.965		
	Total	602.3	62			

$MSE_{(curve)} = 4.965$; $r^2 = 0.50$.

84 cohort using equation (a)

Parameters	SE	$t_{(0.01(1)132)} \approx 2.61$	P
$L_\infty = 48.35$	2.413	20.04	< 0.01
$K = 0.0193$	0.00192	10.05	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	1169	1	1169	201.2	< 0.01
	Error	766.7	132	5.808		
	Total	1935	133			

$MSE_{(curve)} = 5.808; r^2 = 0.60.$

85 cohort

Parameters	SE	$t_{(0.01(1)510)} \approx 2.58$	P
$\mathbf{L_\infty} = 34.29$	0.781	43.90	< 0.01
$K = 0.0394$	0.00260	15.15	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	1027	1	1027	204.9	< 0.01
	Error	2556	510	5.011		
	Total	3582	511			

$MSE_{(curve)} = 5.011; r^2 = 0.29.$

86 cohort

Parameters	SE	$t_{(0.01(1)510)} \approx 2.58$	P
$\mathbf{L_\infty} = 31.94$	0.593	53.86	< 0.01
$K = 0.0521$	0.00327	15.93	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	892.7	1	892.7	222.7	< 0.01
	Error	1511	377	4.009		
	Total	2404	378			

$MSE_{(curve)} = 4.009; r^2 = 0.37.$

APPENDIX 4

APPENDIX 4.1

Summary of analyses used to group populations according to the significance of differences between frequency distribution analyses of morphometric variables.

Variable	Groups	Kruskal-Wallis AOV	Regions grouped
(BD)			
	HP ≈ ST ≈ DO	$Q_{(1-3)}$=3.23; $Q_{(0.01,5)}$=3.29	Guam
	ST ≈ DO ≈ SU	$Q_{(2-4)}$=1.98; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	DA	$Q_{(4-5)}$=6.58; $Q_{(0.01,5)}$=3.29	GBR
(UW)			
	HP ≈ ST	$Q_{(1-2)}$=2.77; $Q_{(0.01,5)}$=3.29	Guam
	ST ≈ SU ≈ DO	$Q_{(2-4)}$=2.04; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	DA	$Q_{(4-5)}$=5.89; $Q_{(0.01,5)}$=3.29	GBR
(WET)			
	HP ≈ ST	$Q_{(1-2)}$=1.73; $Q_{(0.01,5)}$=3.29	Guam
	ST ≈ SU ≈ DO	$Q_{(2-4)}$=1.81; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	DA	$Q_{(4-5)}$=6.22; $Q_{(0.01,5)}$=3.29	GBR
(S)			
	HP ≈ ST ≈ SU ≈ DO	$Q_{(1-4)}$=1.98; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	DA	$Q_{(4-5)}$=7.98; $Q_{(0.01,5)}$=3.29	GBR
(WS			
	HP ≈ ST ≈ SU ≈ DO	$Q_{(1-4)}$=3.10; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	DA	$Q_{(4-5)}$=6.83; $Q_{(0.01,5)}$=3.29	GBR
POA			
	HP ≈ ST	$Q_{(1-2)}$=2.71; $Q_{(0.01,5)}$=3.29	Guam
	ST ≈ DO ≈ SU	$Q_{(2-4)}$=2.09; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	DA	$Q_{(4-5)}$=5.30; $Q_{(0.01,5)}$=3.29	GBR
SOA			
	HP ≈ ST	$Q_{(1-2)}$=2.87; $Q_{(0.01,5)}$=3.29	Guam
	ST ≈ DO ≈ SU	$Q_{(2-4)}$=1.86; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	DA	$Q_{(4-5)}$=5.53; $Q_{(0.01,5)}$=3.29	GBR
IBA			
	HP	$Q_{(1-2)}$=3.59; $Q_{(0.01,5)}$=3.29	Guam
	ST ≈ DO ≈ SU	$Q_{(2-4)}$=1.93; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	DA	$Q_{(4-5)}$=4.10; $Q_{(0.01,5)}$=3.29	GBR
MA			
	HP ≈ ST	$Q_{(1-2)}$=2.63; $Q_{(0.01,5)}$=3.29	Guam
	ST ≈ DO	$Q_{(2-3)}$=1.32; $Q_{(0.01,5)}$=3.29	Guam
	DO ≈ SU	$Q_{(3-4)}$=2.10; $Q_{(0.01,5)}$=3.29	Guam/Fiji
	SU ≈ DA	$Q_{(4-5)}$=3.07; $Q_{(0.01,5)}$=3.29	Fiji/GBR

APPENDIX 4.2.

Bartlett's test of equal variances, one-way ANOVA and comparison of means test for 9 variables among 5 populations. Where; HP = Hospital Point, ST = South Tumon Bay, DO = Double Reef, SU = Suva Reef, DA = Davies Reef.

Variable	Heteroscedasticity	One-way AOV		Comparison of mean ranks
(BD)	$\mathbf{B}(\chi^2) = 43.46$; P< 0.01	$\mathbf{K\text{-}W}_{(stat.)} = 296.9$; P< 0.01		
	view residual plot	Population	Mean Rank	HP ≈ ST ≈ DO
	use non-param.	(1) HP	29.6	$\mathbf{Q}_{(1-3)}=3.23$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(2) ST	69.9	ST ≈ DO ≈ SU
		(3) DO	111.8	$\mathbf{Q}_{(2-4)}=1.98$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(4) SU	122.4	DA
		(5) DA	261.6	$\mathbf{Q_{(4-5)}=6.58}$; $\mathbf{Q}_{(0.01,5)}=3.29$
(UW)	$\mathbf{B}(\chi^2) = 115.24$; P< 0.01	$\mathbf{K\text{-}W}_{(stat.)} = 207.9$; P< 0.01		
	view residual plot	Population	Mean Rank	HP ≈ ST
	use non-param.	(1) HP	27.6	$\mathbf{Q}_{(1-2)}=2.77$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(2) ST	74.9	ST ≈ SU ≈ DO
		(3) SU	107.0	$\mathbf{Q}_{(2-4)}=2.04$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(4) DO	110.6	DA
		(5) DA	201.5	$\mathbf{Q_{(4-5)}=5.89}$; $\mathbf{Q}_{(0.01,5)}=3.29$
(WET)	$\mathbf{B}(\chi^2) = 149.23$; P< 0.01	$\mathbf{K\text{-}W}_{(stat.)} = 292.6$; P< 0.01		
	view residual plot	Population	Mean Rank	HP ≈ ST
	use non-param.	(1) HP	26.3	$\mathbf{Q}_{(1-2)}=1.73$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(2) ST	69.0	ST ≈ SU ≈ DO
		(3) SU	117.0	$\mathbf{Q}_{(2-4)}=1.81$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(4) DO	128.8	DA
		(5) DA	260.4	$\mathbf{Q_{(4-5)}=6.22}$; $\mathbf{Q}_{(0.01,5)}=3.29$
(S)	$\mathbf{B}(\chi^2) = 58.55$; P< 0.01	$\mathbf{K\text{-}W}_{(stat.)} = 298.3$; P< 0.01		
	view residual plot	Population	Mean Rank	HP ≈ ST ≈ SU ≈ DO
	use non-param.	(1) HP	50.1	$\mathbf{Q}_{(1-4)}=1.98$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(2) ST	52.1	DA
		(3) SU	100.2	$\mathbf{Q}_{(4-5)}=7.98$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(4) DO	112.1	
		(5) DA	255.8	
(WS)	$\mathbf{B}(\chi^2) = 68.16$; P< 0.01	$\mathbf{K\text{-}W}_{(stat.)} = 282.7$; P< 0.01		
	view residual plot	Population	Mean Rank	HP ≈ ST ≈ SU ≈ DO
	use non-param.	(1) HP	40.8	$\mathbf{Q}_{(1-4)}=3.10$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(2) ST	55.5	DA
		(3) DO	96.6	$\mathbf{Q}_{(4-5)}=6.83$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(4) SU	113.6	
		(5) DA	255.8	
(POA)	$\mathbf{B}(\chi^2) = 78.67$; P< 0.01	$\mathbf{K\text{-}W}_{(stat.)} = 169.59$; P< 0.01		
	view residual plot	Population	Mean Rank	HP ≈ ST
	use non-param.	(1) HP	34.1	$\mathbf{Q}_{(1-2)}=2.71$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(2) ST	75.4	ST ≈ DO ≈ SU
		(3) DO	101.2	$\mathbf{Q}_{(2-4)}=2.09$; $\mathbf{Q}_{(0.01,5)}=3.29$
		(4) SU	109.6	DA
		(5) DA	185.0	$\mathbf{Q}_{(4-5)}=5.30$; $\mathbf{Q}_{(0.01,5)}=3.29$

(SOA)	$B(\chi^2) = 52.42$; $P< 0.01$	$K\text{-}W_{(stat.)} = 140.70$; $P< 0.01$		
	view residual plot	Population	Mean Rank	HP ≈ ST
	use non-param.	(1) HP	37.0	$Q_{(1\text{-}2)}=2.87$; $Q_{(0.01,5)}=3.29$
		(2) ST	76.0	ST ≈ DO ≈ SU
		(3) SU	96.9	$Q_{(2\text{-}4)}=1.86$; $Q_{(0.01,5)}=3.29$
		(4) DO	102.1	DA
		(5) DA	172.8	$Q_{(4\text{-}5)}=5.53$; $Q_{(0.01,5)}=3.29$
(IBA)	$B(\chi^2) = 66.30$; $P< 0.01$	$K\text{-}W_{(stat.)} = 145.34$; $P< 0.01$		
	view residual plot	Population	Mean Rank	HP
	use non-param.	(1) HP	31.4	$Q_{(1\text{-}2)}=3.59$; $Q_{(0.01,5)}=3.29$
		(2) ST	85.8	ST ≈ DO ≈ SU
		(3) SU	103.8	$Q_{(2\text{-}4)}=1.93$; $Q_{(0.01,5)}=3.29$
		(4) DO	117.3	DA
		(5) DA	175.9	$Q_{(4\text{-}5)}=4.10$; $Q_{(0.01,5)}=3.29$
(MA)	$B(\chi^2) = 181.62$; $P< 0.01$	$K\text{-}W_{(stat.)} = 129.76$; $P< 0.01$		
	view residual plot	Population	Mean Rank	HP ≈ ST
	use non-param.	(1) HP	37.7	$Q_{(1\text{-}2)}=2.63$; $Q_{(0.01,5)}=3.29$
		(2) ST	73.2	ST ≈ DO
		(3) SU	91.6	$Q_{(2\text{-}3)}=1.32$; $Q_{(0.01,5)}=3.29$
		(4) DO	123.5	DO ≈ SU
		(5) DA	164.9	$Q_{(3\text{-}4)}=2.10$; $Q_{(0.01,5)}=3.29$
				SU ≈ DA
				$Q_{(4\text{-}5)}=3.07$; $Q_{(0.01,5)}=3.29$

APPENDIX 4.3A

Test for differences in frequency distributions of sex using two sample t-test (t) when normality and equal variance assumptions are met or Mann-Whitney U-test (M) when these criteria are not met.

Reef:	Davies Reef	Hospital Pt.	Sth. Tumon	Double Reef	Suva Reef
	n_m=52; n_f=40	n_m=22; n_f=18	n_m=19; n_f=21	n_m=20; n_f=16	n_m=27;n_f=29
Variable					
(BD)	t = 2.39 P = 0.36	M = 0.20 P = 0.86	t = -0.05 P = 0.96	t = 1.54 P = 0.13	M = 1.51 P = 0.13
(UW)	t = 0.94 P = 0.35	t = -0.16 P = 0.87	t = -0.96 P = 0.34	t = 1.75 P = 0.09	t = -0.89 P = 0.38
(WET)	t = 3.58 P < 0.01*	t = -0.19 P = 0.85	t = -0.71 P = 0.48	t = 1.17 P = 0.25	t = -1.04 P = 0.30
(S)	t = -0.58 P = 0.56	t = -1.37 P = 0.18	t = -0.93 P = 0.36	M = 1.04 P = 0.30	t = -1.28 P = 0.21
(WS)	t = 0.34; P = 0.73	t = -1.79 P = 0.08	t = -0.22 P = 0.83	M = 0.80 P = 0.43	t = -1.53 P = 0.13
(POA)	t = 1.59 P = 0.12	t = -0.34 P = 0.73	t = -0.02 P = 0.98	t = 1.33 P = 0.19	t = -1.28 P = 0.21
(SOA)	t = 1.35 P = 0.18	t = -0.78 P = 0.44	t = 0.16 P = 0.88	t = 1.97 P = 0.08	t = -1.06 P = 0.30
(IBA)	M = 1.21 P = 0.17	t = 0.35 P = 0.73	t = 0.17 P = 0.86	t = 0.32 P = 0.75	t = -1.13 P = 0.27
(MA)	M = 1.29 P = 0.20	t = -0.18 P = 0.86	M = 0.77 P = 0.44	t = 0.79 P = 0.44	t = -0.05 P = 0.96

where: n_m= number of male starfish
n_f= number of female starfish

APPENDIX 4.3B

Test for differences in sex (omitting immature starfish from population samples) using least squares linear regression analyses of whole body and skeletal ossicle variables for slope and elevation from 5 populations (where: (BD) = whole body diameter (cm); (UW) = underwater weight (g); (WET) = whole wet weight (g); S = spine ossicle length (mm); WS = whole spine length (spine + pedicel length) (mm); POA = primary oral ossicle weight (adjusted for number of arms) (g); SOA = secondary oral ossicle weight (adjusted for number of arms); IBA = inter-brachial ossicle weight (adjusted for number of arms) (g); MA = madreporite weight (adjusted for number of madreporites) (g).

Whole body diameter (cm)

Davies Reef

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) $(UW) = 0.107 \times (BD)^{1.872}$	$r^2=0.58$; n=92; $p< 0.01$; $MSE=3.32\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.42$, $\mathbf{F}_{(\alpha1;0.01;2,92)}=4.82$, $p>0.25$
(b) $(WET) = 0.281 \times (BD)^{2.434}$	$r^2=0.79$; n=211; $p< 0.01$; $MSE=2.24\times10^{-2}$ $\mathbf{F}_{(ratio)}=4.48$, $\mathbf{F}_{(\alpha1;0.01;2,211)}=4.68$, $0.025>p>0.01$
(c) $S = 12.804 \times (BD)^{0.254}$	$r^2=0.05$; n=194; $p< 0.01$; $MSE=1.64\times10^{-2}$ $\mathbf{F}_{(ratio)}=1.42$, $\mathbf{F}_{(\alpha1;0.01;2,194)}=4.71$, $0.25>p>0.1$
(d) $WS = 14.845 \times (BD)^{0.338}$	$r^2=0.07$; n=168; $p< 0.01$; $MSE=2.06\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.77$, $\mathbf{F}_{(\alpha1;0.01;2,168)}=4.73$, $p>0.25$
(e) $POA = (1.650\times10^{-2}) \times (BD)^{1.424}$	$r^2=0.42$; n=60; $p< 0.01$; $MSE=3.80\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.85$, $\mathbf{F}_{(\alpha1;0.01;2,60)}=4.98$, $p>0.25$
(f) $SOA = (1.12\times10^{-2}) \times (BD)^{1.439}$	$r^2=0.42$; n=64; $p< 0.01$; $MSE=3.99\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.56$, $\mathbf{F}_{(\alpha1;0.01;2,64)}=4.88$, $p>0.25$
(g) $IBA = (2.185\times10^{-2}) \times (BD)^{1.407}$	$r^2=0.34$; n=59; $p< 0.01$; $MSE=5.46\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.68$, $\mathbf{F}_{(\alpha1;0.01;2,59)}=4.98$, $p>0.25$
(h) $MA = (3.490\times10^{-5}) \times (BD)^{2.026}$	$r^2=0.20$; n=35; $p=0.01$; $MSE=0.227$ $\mathbf{F}_{(ratio)}=0.40$, $\mathbf{F}_{(\alpha1;0.01;2,35)}=5.27$, $p>0.25$

Whole body diameter (cm)

Hospital Point

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) (UW) = $(8.346\times10^{-2}) \times (BD)^{2.573}$	$r^2=0.72$; n=40; p< 0.01; MSE=2.63×10^{-2} $\mathbf{F}_{(ratio)}=0.28$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, p>0.25
(b) (WET) = $0.179 \times (BD)^{2.503}$	$r^2=0.72$; n=40; p< 0.01; MSE=2.43×10^{-2} $\mathbf{F}_{(ratio)}=0.61$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, p>0.25
(c) S = not significant	$r^2=0.002$; n=40; p=0.78
(d) WS = not significant	$r^2=0.001$; n=40; p=0.89
(e) POA = $(9.44\times10^{-3}) \times (BD)^{1.540}$	$r^2=0.38$; n=40; p< 0.01; MSE=3.93×10^{-2} $\mathbf{F}_{(ratio)}=0.39$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, p>0.25
(f) SOA = $(5.09\times10^{-3}) \times (BD)^{1.606}$	$r^2=0.35$; n=40; p< 0.01; MSE=4.99×10^{-2} $\mathbf{F}_{(ratio)}=0.72$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, p>0.25
(g) IBA = $(8.42\times10^{-4}) \times (BD)^{1.651}$	$r^2=0.39$; n=40; p=0.01; MSE=4.29×10^{-2} $\mathbf{F}_{(ratio)}=0.53$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, p>0.25
(h) MA = $(2.172\times10^{-4}) \times (BD)^{1.330}$	$r^2=0.09$; n=40; p=0.01; MSE=0.194 $\mathbf{F}_{(ratio)}=0.26$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, p>0.25

Whole body diameter (cm)

South Tumon Bay

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) (UW) = $(9.963x10^{-3})$ x $(BD)^{2.557}$	r^2=0.67; n=40; p< 0.01; MSE=$3.04x10^{-2}$ $\mathbf{F}_{(ratio)}$=1.41, $\mathbf{F}_{(\alpha1;0.01;2,40)}$=5.18, 0.25>p>0.10
(b) (UW) = $(4.550x10^{-2})$ x $(BD)^{2.951}$	r^2=0.66; n=40; p< 0.01; MSE=$4.29x10^{-2}$ $\mathbf{F}_{(ratio)}$=0.53, $\mathbf{F}_{(\alpha1;0.01;2,40)}$=5.18, 0.25>p>0.10
(c) S = not significant	r^2=0.21; n=40; p=0.03
(d) WS = not significant	r^2=0.08; n=40; p=0.08
(e) POA = $(7.65x10^{-3})$ x $(BD)^{1.627}$	r^2=0.47; n=40; p< 0.01; MSE=$2.81x10^{-2}$ $\mathbf{F}_{(ratio)}$=0.33, $\mathbf{F}_{(\alpha1;0.01;2,40)}$=5.18, p>0.25
(f) SOA = $(4.42x10^{-3})$ x $(BD)^{1.670}$	r^2=0.38; n=40; p< 0.01; MSE=$4.37x10^{-2}$ $\mathbf{F}_{(ratio)}$=1.14, $\mathbf{F}_{(\alpha1;0.01;2,40)}$=5.18, p>0.25
(g) IBA = $(8.13x10^{-4})$ x $(BD)^{1.715}$	r^2=0.37; n=40; p< 0.01; MSE=$4.82x10^{-2}$ $\mathbf{F}_{(ratio)}$=0.15, $\mathbf{F}_{(\alpha1;0.01;2,40)}$=5.18, p>0.25
(h) MA = $(1.10x10^{-5})$ x $(BD)^{2.310}$	r^2=0.34; n=40; p< 0.01; MSE=$9.64x10^{-2}$ $\mathbf{F}_{(ratio)}$=0.15, $\mathbf{F}_{(\alpha1;0.01;2,40)}$=5.18, p>0.25

Whole body diameter (cm)

Double Reef

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) (UW) = $(5.38 \times 10^{-3}) \times (BD)^{2.732}$	$r^2=0.91$; n=38; $p< 0.01$; MSE=1.43×10^{-2} $\mathbf{F}_{(ratio)}=2.53$, $\mathbf{F}_{(\alpha 1;0.01;2,38)}=5.18$, $0.10>p>0.05$
(b) (WET) = $0.624 \times (BD)^{2.219}$	$r^2=0.73$; n=36; $p< 0.01$; MSE=1.70×10^{-2} $\mathbf{F}_{(ratio)}=0.82$, $\mathbf{F}_{(\alpha 1;0.01;2,36)}=5.18$, $p>0.25$
(c) S = not significant	$r^2=0.08$; n=35; p=0.47
(d) WS = not significant	$r^2=0.01$; n=35; p=0.68
(e) POA = $(6.20 \times 10^{-4}) \times (BD)^{2.349}$	$r^2=0.76$; n=37; $p< 0.01$; MSE=3.50×10^{-2} $\mathbf{F}_{(ratio)}=4.34$, $\mathbf{F}_{(\alpha 1;0.01;2,37)}=5.18$, $0.025>p>0.01$
(f) SOA = $(3.97 \times 10^{-4}) \times (BD)^{2.366}$	$r^2=0.76$; n=37; $p< 0.01$; MSE=3.69×10^{-2} $\mathbf{F}_{(ratio)}=3.31$, $\mathbf{F}_{(\alpha 1;0.01;2,37)}=5.18$, $0.05>p>0.025$
(g) IBA = $(1.17 \times 10^{-4}) \times (BD)^{2.258}$	$r^2=0.72$; n=37; $p< 0.01$; MSE=4.16×10^{-2} $\mathbf{F}_{(ratio)}=1.31$, $\mathbf{F}_{(\alpha 1;0.01;2,37)}=5.18$, $p>0.25$
(h) MA = $(1.93 \times 10^{-5}) \times (BD)^{2.119}$	$r^2=0.43$; n=37; $p< 0.01$; MSE=0.121 $\mathbf{F}_{(ratio)}=0.43$, $\mathbf{F}_{(\alpha 1;0.01;2,35)}=5.18$, $p>0.25$

Whole body diameter (cm)

Suva Reef

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) $(UW) = (2.29 \times 10^{-2}) \times (BD)^{2.269}$	$r^2=0.84$; n=56; $p< 0.01$; $MSE=4.41 \times 10^{-2}$ $\mathbf{F}_{(ratio)}=0.79$, $\mathbf{F}_{(\alpha 1;0.01;2,56)}=4.98$, $p>0.25$
(b) $(WET) = (5.18 \times 10^{-2}) \times (BD)^{2.894}$	$r^2=0.92$; n=56; $p< 0.01$; $MSE=3.07 \times 10^{-2}$ $\mathbf{F}_{(ratio)}=0.23$, $\mathbf{F}_{(\alpha 1;0.01;2,56)}=4.98$, $p>0.25$
(c) $S = 0.715 \times (WET)^{0.990}$	$r^2=0.75$; n=56; $p< 0.01$; $MSE=1.42 \times 10^{-2}$ $\mathbf{F}_{(ratio)}=0.12$, $\mathbf{F}_{(\alpha 1;0.01;2,56)}=4.98$, $p>0.25$
(d) $WS = 0.558 \times (WET)^{1.179}$	$r^2=0.77$; n=56; $p< 0.01$; $MSE=1.91 \times 10^{-2}$ $\mathbf{F}_{(ratio)}=0.47$, $\mathbf{F}_{(\alpha 1;0.01;2,56)}=4.98$, $p>0.25$
(e) $POA = (3.77 \times 10^{-3}) \times (WET)^{2.470}$	$r^2=0.85$; n=56; $p< 0.01$; $MSE=4.65 \times 10^{-2}$ $\mathbf{F}_{(ratio)}=0.39$, $\mathbf{F}_{(\alpha 1;0.01;2,37)}=4.98$, $p>0.25$
(f) $SOA = (3.35 \times 10^{-4}) \times (WET)^{2.374}$	$r^2=0.86$; n=56; $p< 0.01$; $MSE=4.22 \times 10^{-2}$ $\mathbf{F}_{(ratio)}=0.32$, $\mathbf{F}_{(\alpha 1;0.01;2,56)}=4.98$, $p>0.25$
(g) $IBA = (6.50 \times 10^{-5}) \times (WET)^{2.421}$	$r^2=0.90$; n=56; $p=0.01$; $MSE=2.89 \times 10^{-2}$ $\mathbf{F}_{(ratio)}=0.02$, $\mathbf{F}_{(\alpha 1;0.01;2,56)}=4.98$, $p>0.25$
(h) $MA = (1.40 \times 10^{-5}) \times (WET)^{2.275}$	$r^2=0.63$; n=56; $p=0.01$; $MSE=0.127$ $\mathbf{F}_{(ratio)}=1.34$, $\mathbf{F}_{(\alpha 1;0.01;2,56)}=4.98$, $p>0.25$

Underwater weight (g)

Davies Reef

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) (BD) = 9.29 x $(UW)^{0.312}$	r^2=0.58; n=92; p< 0.01; MSE=5.47x10^{-3} $\mathbf{F}_{(ratio)}$=1.25, $\mathbf{F}_{(\alpha 1;0.01;2,92)}$=4.82, p>0.25
(b) (WET) = 26.68 x $(UW)^{0.942}$	r^2=0.67; n=92; p< 0.01; MSE=3.50x10^{-2} $\mathbf{F}_{(ratio)}$=3.72, $\mathbf{F}_{(\alpha 1;0.01;2,92)}$=4.82, p>0.25
(c) S = 13.16 x $(UW)^{0.190}$	r^2=0.13; n=91; p< 0.01; MSE=1.96x10^{-2} $\mathbf{F}_{(ratio)}$=1.03, $\mathbf{F}_{(\alpha 1;0.01;2,91)}$=4.82, p>0.25
(d) WS = 18.96 x $(UW)^{0.205}$	r^2=0.12; n=90; p< 0.01; MSE=2.46x10^{-2} $\mathbf{F}_{(ratio)}$=1.24, $\mathbf{F}_{(\alpha 1;0.01;2,90)}$=4.85, p>0.25
(e) POA = 0.168 x $(UW)^{0.624}$	r^2=0.63; n=36; p< 0.01; MSE=2.72x10^{-2} $\mathbf{F}_{(ratio)}$= not tested
(f) SOA = 0.017 x $(UW)^{1.029}$	r^2=0.77; n=6; p=0.021; MSE=2.78x10^{-2} $\mathbf{F}_{(ratio)}$= not tested
(g) IBA = 0.013 x $(UW)^{0.721}$	r^2=0.62; n=36; p< 0.01; MSE=3.74x10^{-2} $\mathbf{F}_{(ratio)}$= not tested
(h) MA = (8.08 x 10^{-4}) x $(UW)^{0.911}$	r^2=0.32; n=36; p< 0.01; MSE=0.208 $\mathbf{F}_{(ratio)}$= not tested

Underwater weight (g)

Hospital Point

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) $(BD) = 9.248 \times (UW)^{0.280}$	$r^2=0.72$; n=40; $p< 0.01$; $MSE=2.85\times10^{-3}$ $\mathbf{F}_{(ratio)}=0.43$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$
(b) $(WET) = 22.392 \times (UW)^{0.921}$	$r^2=0.90$; n=40; $p< 0.01$; $MSE=8.60\times10^{-3}$ $\mathbf{F}_{(ratio)}=1.92$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $0.25>p>0.1$
(c) S = not significant	$r^2=0.01$; n=40; p=0.39
(d) WS = not significant	$r^2=0.10$; n=40; p=0.13
(e) $POA = 0.132 \times (UW)^{0.668}$	$r^2=0.66$; n=40; $p< 0.01$; $MSE=2.17\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.81$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$
(f) $SOA = 0.092 \times (UW)^{0.652}$	$r^2=0.52$; n=40; $p< 0.01$; $MSE=3.64\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.81$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$
(g) $IBA = (1.74\times10^{-2}) \times (UW)^{0.654}$	$r^2=0.57$; n=40; $p< 0.01$; $MSE=3.06\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.95$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$
(h) $MA = (1.16 \times 10^{-3}) \times (UW)^{0.758}$	$r^2=0.25$; n=40; p=0.01; MSE=0.158 $\mathbf{F}_{(ratio)}=0.26$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$

Underwater weight (g)

South Tumon Bay

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) (BD) = 9.911 x $(UW)^{0.262}$	$r^2=0.67$; n=40; p< 0.01; MSE=3.11×10^{-3} $\mathbf{F}_{(ratio)}=1.12$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, 0.25>p>0.10
(b) (WET) = 12.724 x $(UW)^{1.071}$	$r^2=0.85$; n=40; p< 0.01; MSE=1.93×10^{-2} $\mathbf{F}_{(ratio)}=0.78$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, 0.25>p>0.10
(c) S = not significant	$r^2=0.13$; n=40; p=0.02
(d) WS = not significant	$r^2=0.05$; n=40; p=0.15
(e) POA = 0.116 x $(UW)^{0.693}$	$r^2=0.83$; n=40; p< 0.01; MSE=8.90×10^{-3} $\mathbf{F}_{(ratio)}=3.35$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, 0.05>p>0.01
(f) SOA = 0.065 x $(UW)^{0.737}$	$r^2=0.72$; n=40; p< 0.01; MSE=2.00×10^{-2} $\mathbf{F}_{(ratio)}=3.54$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, 0.05>p>0.01
(g) IBA = (1.30×10^{-2}) x $(UW)^{0.755}$	$r^2=0.69$; n=40; p=0.01; MSE=2.34×10^{-2} $\mathbf{F}_{(ratio)}=1.96$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, 0.25>p>0.1
(h) MA = (8.79×10^{-4}) x $(UW)^{0.846}$	$r^2=0.45$; n=40; p=0.01; MSE=8.07×10^{-2} $\mathbf{F}_{(ratio)}=0.06$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, p>0.25

Underwater weight (g)

Double Reef

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) $(BD) = 7.700 \times (UW)^{0.334}$	$r^2=0.91$; $n=38$; $p< 0.01$; $MSE=1.74\times10^{-3}$ $\mathbf{F}_{(ratio)}=0.15$, $\mathbf{F}_{(\alpha1;0.01;2,38)}=5.18$, $p>0.25$
(b) $(WET) = 13.652 \times (UW)^{1.094}$	$r^2=0.93$; $n=38$; $p< 0.01$; $MSE=1.53\times10^{-2}$ $\mathbf{F}_{(ratio)}=3.96$, $\mathbf{F}_{(\alpha1;0.01;2,38)}=5.18$, $0.05>p>0.01$
(c) $S = 7.822 \times (UW)^{0.256}$	$r^2=0.37$; $n=37$; $p< 0.01$; $MSE=1.81\times10^{-2}$ $\mathbf{F}_{(ratio)}=$ not tested
(d) $WS = 8.951 \times (UW)^{0.308}$	$r^2=0.40$; $n=37$; $p< 0.01$; $MSE=2.39\times10^{-2}$ $\mathbf{F}_{(ratio)}=$ not tested
(e) $POA = (4.38\times10^{-2}) \times (UW)^{0.919}$	$r^2=0.93$; $n=37$; $p< 0.01$; $MSE=2.51\times10^{-2}$ $\mathbf{F}_{(ratio)}=5.13$, $\mathbf{F}_{(\alpha1;0.01;2,37)}=5.18$, $0.025>p>0.01$
(f) $SOA = (2.81\times10^{-2}) \times (UW)^{0.932}$	$r^2=0.94$; $n=37$; $p< 0.01$; $MSE=2.33\times10^{-2}$ $\mathbf{F}_{(ratio)}=4.28$, $\mathbf{F}_{(\alpha1;0.01;2,37)}=5.18$, $0.025>p>0.01$
(g) $IBA = (8.354\times10^{-3}) \times (UW)^{0.840}$	$r^2=0.80$; $n=37$; $p< 0.01$; $MSE=2.87\times10^{-2}$ $\mathbf{F}_{(ratio)}= 0.31$, $\mathbf{F}_{(\alpha1;0.01;2,37)}=5.18$, $p>0.25$
(h) $MA = (6.90 \times 10^{-4}) \times (UW)^{0.893}$	$r^2=0.64$; $n=38$; $p< 0.01$; $MSE=0.119$ $\mathbf{F}_{(ratio)}=1.05$, $\mathbf{F}_{(\alpha1;0.01;2,35)}=5.18$, $p>0.25$

Underwater weight (g)

Suva Reef

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) $(BD) = 6.900 \times (UW)^{0.369}$	$r^2=0.84$; n=56; p< 0.01; $MSE=7.16\times10^{-3}$ $\mathbf{F}_{(ratio)}=0.04$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, p>0.25
(b) $(WET) = 10.771 \times (UW)^{1.135}$	$r^2=0.87$; n=56; p< 0.01; $MSE=5.05\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.79$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, p>0.25
(c) $S = 4.393 \times (UW)^{0.391}$	$r^2=0.72$; n=56; p< 0.01; $MSE=1.59\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.58$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, p>0.25
(d) $WS = 4.962 \times (UW)^{0.460}$	$r^2=0.72$; n=56; p< 0.01; $MSE=2.27\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.87$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, p>0.25
(e) $POA = (3.06\times10^{-2}) \times (UW)^{1.011}$	$r^2=0.88$; n=56; p< 0.01; $MSE=3.81\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.52$, $\mathbf{F}_{(\alpha1;0.01;2,37)}=4.98$, p>0.25
(f) $SOA = (2.35\times10^{-2}) \times (UW)^{0.966}$	$r^2=0.87$; n=56; p< 0.01; $MSE=3.89\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.26$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, p>0.25
(g) $IBA = (5.04\times10^{-3}) \times (UW)^{0.979}$	$r^2=0.88$; n=56; p< 0.01; $MSE=3.28\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.76$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, p>0.25
(h) $MA = (7.85 \times 10^{-4}) \times (UW)^{0.938}$	$r^2=0.65$; n=56; p=0.01; MSE=0.121 $\mathbf{F}_{(ratio)}=2.02$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, 0.25>p>0.1

Whole wet weight (g)

Davies Reef

equation	statistics and $F_{(ratio)}$ test for sex
(a) (BD) = $3.281 \times (WET)^{0.324}$	$r^2=0.78$; n=211; p< 0.01; MSE=2.98×10^{-3} $F_{(ratio)}=1.0$, $F_{(\alpha1;0.01;2,211)}=4.68$, p>0.25
(b) (UW) = $0.463 \times (WET)^{0.708}$	$r^2=0.67$; n=92; p< 0.01; MSE=2.63×10^{-2} $F_{(ratio)}=0.93$, $F_{(\alpha1;0.01;2,92)}=4.82$, p>0.25
(c) S = $17.49 \times (WET)^{0.081}$	$r^2=0.04$; n=194; p< 0.01; MSE=1.65×10^{-2} $F_{(ratio)}=1.79$, $F_{(\alpha1;0.01;2,194)}=4.71$, 0.25>p>0.1
(d) WS = $24.82 \times (WET)^{0.095}$	$r^2=0.04$; n=168; p=0.01; MSE=2.11×10^{-2} $F_{(ratio)}=0.95$, $F_{(\alpha1;0.01;2,168)}=4.73$, p>0.25
(e) POA = $0.047 \times (WET)^{0.545}$	$r^2=0.44$; n=60; p< 0.01; MSE=3.63×10^{-2} $F_{(ratio)}=0.78$, $F_{(\alpha1;0.01;2,60)}=4.98$, p>0.25
(f) SOA = $0.068 \times (WET)^{0.453}$	$r^2=0.30$; n=64; p< 0.01; MSE=4.80×10^{-2} $F_{(ratio)}=0.28$, $F_{(\alpha1;0.01;2,64)}=4.88$, p>0.25
(g) IBA = $0.012 \times (WET)^{0.451}$	$r^2=0.30$;n=59;p=0.01;MSE=6.15×10^{-2} $F_{(ratio)}=0.43$, $F_{(\alpha1;0.01;2,60)}=4.98$, p>0.25
(h) MA = $(1.34 \times 10^{-4}) \times (WET)^{0.792}$	$r^2=0.21$;n=35;p=0.01;MSE=0.222 $F_{(ratio)}=0.35$, $F_{(\alpha1;0.01;2,35)}=5.27$, p>0.25

Whole wet weight (g)

Hospital Point

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) $(BD) = 3.931 \times (WET)^{0.289}$	$r^2=0.72$; $n=40$; $p< 0.01$; $MSE=2.91\times10^{-3}$ $\mathbf{F}_{(ratio)}=0.31$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, $p>0.25$
(b) $(UW) = 0.066 \times (WET)^{0.980}$	$r^2=0.90$; $n=40$; $p< 0.01$; $MSE=9.28\times10^{-3}$ $\mathbf{F}_{(ratio)}=0.74$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, $p>0.25$
(c) S = not significant	$r^2=0.01$; $n=40$; $p=0.50$
(d) WS = not significant	$r^2=0.02$; $n=40$; $p=0.41$
(e) $POA = 0.019 \times (WET)^{0.676}$	$r^2=0.64$; $n=40$; $p< 0.01$; $MSE=2.32\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.17$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, $p>0.25$
(f) $SOA = 0.013 \times (WET)^{0.671}$	$r^2=0.52$; $n=40$; $p< 0.01$; $MSE=3.66\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.51$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, $p>0.25$
(g) $IBA = (3.14\times10^{-3}) \times (WET)^{0.630}$	$r^2=0.50$; $n=40$; $p=0.01$; $MSE=3.57\times10^{-2}$ $\mathbf{F}_{(ratio)}=1.16$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, $p>0.25$
(h) $MA = (8.03 \times 10^{-5}) \times (WET)^{0.840}$	$r^2=0.29$; $n=40$; $p=0.01$; $MSE=0.150$ $\mathbf{F}_{(ratio)}=0.14$, $\mathbf{F}_{(\alpha 1;0.01;2,40)}=5.18$, $p>0.25$

Whole wet weight (g)

South Tumon Bay

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) (BD) = $6.149 \times (WET)^{0.223}$	$r^2=0.66$; $n=40$; $p< 0.01$; $MSE=3.23\times10^{-3}$ $\mathbf{F}_{(ratio)}=1.872$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $0.25>p>0.10$
(b) (UW) = $0.242 \times (WET)^{0.789}$	$r^2=0.85$; $n=40$; $p< 0.01$; $MSE=1.42\times10^{-2}$ $\mathbf{F}_{(ratio)}=1.67$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $0.25>p>0.10$
(c) S = not significant	$r^2=0.16$; $n=40$; $p=0.01$
(d) WS = not significant	$r^2=0.08$; $n=40$; $p=0.09$;
(e) POA = $0.046 \times (WET)^{0.537}$	$r^2=0.68$; $n=40$; $p< 0.01$; $MSE=1.71\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.31$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$
(f) SOA = $0.023 \times (WET)^{0.578}$	$r^2=0.60$; $n=40$; $p< 0.01$; $MSE=2.98\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.74$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$
(g) IBA = $(4.02\times10^{-3}) \times (WET)^{0.611}$	$r^2=0.62$; $n=40$; $p=0.01$; $MSE=2.92\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.61$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$
(h) MA = $(2.19 \times 10^{-4}) \times (WET)^{0.696}$	$r^2=0.41$; $n=40$; $p=0.01$; $MSE=8.61\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.02$, $\mathbf{F}_{(\alpha1;0.01;2,40)}=5.18$, $p>0.25$

Whole wet weight (g)

Double Reef

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) (BD) = 3.923 x $(WET)^{0.288}$	r^2=0.87; n=38; p< 0.01; MSE=$2.53x10^{-3}$ $\mathbf{F}_{(ratio)}$=1.01, $\mathbf{F}_{(\alpha1;0.01;2,38)}$=5.18, p>0.25
(b) (UW) = 0.146 x $(WET)^{0.848}$	r^2=0.93; n=38; p< 0.01; MSE=$1.18x10^{-2}$ $\mathbf{F}_{(ratio)}$=0.85, $\mathbf{F}_{(\alpha1;0.01;2,38)}$=5.18, p>0.25
(c) S = 3.82 x $(WET)^{0.249}$	r^2=0.59; n=37; p< 0.01; MSE=$1.27x10^{-2}$ $\mathbf{F}_{(ratio)}$=5.10, $\mathbf{F}_{(\alpha1;0.01;2,37)}$=5.18, 0.02>p>0.01*
(d) WS = 3.79 x $(WET)^{0.299}$	r^2=0.49; n=37; p=0.01; MSE=$2.03x10^{-2}$ $\mathbf{F}_{(ratio)}$=5.75, $\mathbf{F}_{(\alpha1;0.01;2,37)}$=5.18, p< 0.01**
(e) POA = $(8.13x10^{-3})$ x $(WET)^{0.767}$	r^2=0.86; n=37; p< 0.01; MSE=$2.08x10^{-2}$ $\mathbf{F}_{(ratio)}$=0.97, $\mathbf{F}_{(\alpha1;0.01;2,37)}$=5.18, p>0.25
(f) SOA = $(5.31x10^{-3})$ x $(WET)^{0.772}$	r^2=0.85; n=37; p< 0.01; MSE=$2.26x10^{-2}$ $\mathbf{F}_{(ratio)}$=0.44, $\mathbf{F}_{(\alpha1;0.01;2,37)}$=5.18, p>0.25
(g) IBA = $(1.40x10^{-3})$ x $(WET)^{0.736}$	r^2=0.80; n=37; p=0.01; MSE=$2.88x10^{-2}$ $\mathbf{F}_{(ratio)}$=0.88, $\mathbf{F}_{(\alpha1;0.01;2,37)}$=5.18, p>0.25
(h) MA = (2.48×10^{-4}) x $(WET)^{0.658}$	r^2=0.44; n=37; p=0.01; MSE=0.120 $\mathbf{F}_{(ratio)}$=0.05, $\mathbf{F}_{(\alpha1;0.01;2,35)}$=5.18, p>0.25

Whole wet weight (g)

Suva Reef

equation	statistics and $\mathbf{F}_{(ratio)}$ test for sex
(a) $(BD) = 3.314 \times (WET)^{0.319}$	$r^2=0.92$; $n=56$; $p< 0.01$; $MSE=3.38\times10^{-3}$ $\mathbf{F}_{(ratio)}=0.54$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, $p>0.25$
(b) $(UW) = 0.257 \times (WET)^{0.770}$	$r^2=0.87$; $n=56$; $p< 0.01$; $MSE=3.42\times10^{-2}$ $\mathbf{F}_{(ratio)}=1.06$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, $p>0.25$
(c) $S = 2.08 \times (WET)^{0.334}$	$r^2=0.77$; $n=56$; $p< 0.01$; $MSE=1.29\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.22$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, $p>0.25$
(d) $WS = 2.07 \times (WET)^{0.392}$	$r^2=0.77$; $n=56$; $p< 0.01$; $MSE=1.88\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.58$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, $p>0.25$
(e) $POA = (5.28\times10^{-3}) \times (WET)^{0.837}$	$r^2=0.89$; $n=56$; $p< 0.01$; $MSE=3.57\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.62$, $\mathbf{F}_{(\alpha1;0.01;2,37)}=4.98$, $p>0.25$
(f) $SOA = (4.31\times10^{-3}) \times (WET)^{0.802}$	$r^2=0.88$; $n=56$; $p< 0.01$; $MSE=3.38\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.49$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, $p>0.25$
(g) $IBA = (8.73\times10^{-4}) \times (WET)^{0.819}$	$r^2=0.91$; $n=56$; $p=0.01$; $MSE=2.40\times10^{-2}$ $\mathbf{F}_{(ratio)}=0.03$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, $p>0.25$
(h) $MA = (1.65 \times 10^{-4}) \times (WET)^{0.766}$	$r^2=0.63$; $n=56$; $p=0.01$; $MSE=0.126$ $\mathbf{F}_{(ratio)}=1.16$, $\mathbf{F}_{(\alpha1;0.01;2,56)}=4.98$, $p>0.25$

APPENDIX 4.4A

Replication test-of-fit between least squares linear regression analyses and one-way ANOVA for all variables and all estimated ages (using spine ossicle pigment band counts). H_o = the population regression is linear (there is a linear trend), and H_1 = the population relationship is non-linear. Where P(V). = Bartlett's test for equal variances between age groups, * denotes test found unequal variances between age groups (when not tested then inequality assumed); P (rep. tof) = significance of replication test-of-fit between regression and ANOVA analyses.

Davies Reef

	$\mathbf{F}_{(ratio)}$ test		$\mathbf{F}_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	1.10	<	$\mathbf{F}_{(\alpha 1;0.01;5,224)} \approx 3.08$	0.99	>0.25	0.07;< 0.01
(UW)	1.53	<	$\mathbf{F}_{(\alpha 1;0.01;5,121)} \approx 3.15$	0.68	0.25>P>0.1	0.13;< 0.01
(WET)	1.28	<	$\mathbf{F}_{(\alpha 1;0.01;5,224)} \approx 3.08$	0.78	>0.25	0.03; 0.02
(S)	3.77	>	$\mathbf{F}_{(\alpha 1;0.01;5,224)} \approx 3.08$	0.92	< 0.01	0.65;< 0.01
(WS)	2.83	<	$\mathbf{F}_{(\alpha 1;0.01;5,199)} \approx 3.11$	0.86	0.05>P>0.01	0.68;< 0.01
(POA)	1.04	<	$\mathbf{F}_{(\alpha 1;0.01;4,90)} = 3.53$	0.66	>0.25	0.12;< 0.01
(SOA)	0.57	<	$\mathbf{F}_{(\alpha 1;0.01;4,64)} \approx 3.60$	0.06	>0.25	0.05; 0.08
(IBA)	0.99	<	$\mathbf{F}_{(\alpha 1;0.01;4,89)} \approx 3.53$	0.67	>0.25	0.04; 0.06
(MA)	0.79	<	$\mathbf{F}_{(\alpha 1;0.01;4,65)} \approx 3.60$	0.003 *	>0.25	0.14;< 0.01

Hospital Point

	$F_{(ratio)}$ test		$F_{(ratio)}$ critical	P (V)	P (rep. tof.)	r^2; P(reg.)
(BD)	3.09	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	not tested	0.1>P>0.05	0.01; 0.49
(UW)	3.43	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.31	0.1>P>0.05	< 0.01;0.85
(WET)	1.45	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.47	0.25>P>0.1	< 0.01;0.84
(S)	$5.48x10^{-5}$	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.43	>0.25	0.50;< 0.01
(WS)	0.22	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.04	>0.25	0.43;< 0.01
(POA)	1.44	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.91	>0.25	0.05;0.16
(SOA)	0.64	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.97	>0.25	0.04; 0.23
(IBA)	2.33	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.84	0.25>P>0.1	0.07; 0.10
(MA)	0.51	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.26	>0.25	0.02; 0.41

South Tumon Bay

	$F_{(ratio)}$ test		$F_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	1.36	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.76	0.25	0.08; 0.08
(UW)	0.80	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.41	>0.25	0.02; 0.38
(WET)	1.33	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.31	>0.25	0.03; 0.33
(S)	0.27	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.89	>0.25	0.35;< 0.01
(WS)	0.39	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.21	>0.25	0.43;< 0.01
(POA)	0.02	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.70	>0.25	0.06; 0.14
(SOA)	0.04	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.72	>0.25	0.02; 0.39
(IBA)	0.04	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.22	>0.25	< 0.01;0.84
(MA)	0.12	<	$F_{(\alpha1;0.01;1,40)}$ = 7.31	0.49	>0.25	0.03; 0.28

Double Reef

	$F_{(ratio)}$ test		$F_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	17.60	>	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.94	< 0.01	0.21;< 0.01
(UW)	10.58	>	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.17	< 0.01	0.17; 0.01
(WET)	8.13	>	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.23	< 0.01	0.24;< 0.01
(S)	13.58	>	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.08	< 0.01	0.79;< 0.01
(WS)	13.97	>	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.13	< 0.01	0.84;< 0.01
(POA)	16.25	>	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.56	< 0.01	0.35;< 0.01
(SOA)	12.13	>	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.53	< 0.01	0.28;< 0.01
(IBA)	10.36	>	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.58	< 0.01	0.23;< 0.01
(MA)	1.71	<	$F_{(\alpha 1;0.01;3,40)} = 4.31$	0.37	0.25>P>0.1	0.14; 0.02

Suva Reef

	$F_{(ratio)}$ test		$F_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	12.90	>	$F_{(\alpha 1;0.01;4,74)} \approx 3.56$	0.96	< 0.01	0.63;< 0.01
(UW)	3.20	<	$F_{(\alpha 1;0.01;4,74)} \approx 3.56$	< 0.01 *	0.025>P>0.01	0.67< 0.01
(WET)	1.62	<	$F_{(\alpha 1;0.01;4,74)} \approx 3.56$	< 0.01 *	0.25>P>0.1	0.67;< 0.01
(S)	12.77	>	$F_{(\alpha 1;0.01;4,74)} \approx 3.56$	0.09	< 0.01	0.79;< 0.01
(WS)	12.45	>	$F_{(\alpha 1;0.01;4,74)} \approx 3.56$	0.24	< 0.01	0.81;< 0.01
(POA)	5.52	>	$F_{(\alpha 1;0.01;4,74)} \approx 3.56$	< 0.01 *	< 0.01	0.79;< 0.01
(SOA)	3.95	>	$F_{(\alpha 1;0.01;4,74)} \approx 3.56$	< 0.01 *	< 0.01	0.75;< 0.01
(IBA)	5.21	>	$F_{(\alpha 1;0.01;4,74)} \approx 3.56$	< 0.01 *	< 0.01	0.70;< 0.01
(MA)	2.47	<	$F_{(\alpha 1;0.01;4,68)} \approx 3.60$	0.27	0.1>P>0.05	0.48;< 0.01

APPENDIX 4.4B

Replication test-of-fit between least squares linear regression analyses and one-way ANOVA for all variables and estimated age using spine ossicle pigment band counts (selecting mature age classes, where gonads were able to be sexed). H_o = the population regression is linear (there is a linear trend), and H_1 = the population relationship is non-linear. Where (P) vars. = Bartlett's test for equal variances between age groups, * denotes test found unequal variances between age groups (when not tested then inequality assumed); (P) rep. tof = significance of replication test-of-fit between regression and ANOVA analyses (test for linearity).

Davies Reef

	$F_{(ratio)}$ test		$F_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	1.20	<	$F_{(\alpha 1;0.01;5,194)} \approx 3.11$	0.82	>0.25	0.06;< 0.01
(UW)	0.80	<	$F_{(\alpha 1;0.01;4,91)} \approx 3.51$	0.99	>0.25	0.10;< 0.01
(WET)	1.40	<	$F_{(\alpha 1;0.01;5,194)} \approx 3.11$	0.50	>0.25	0.02;<0.04
(S)	3.76	>	$F_{(\alpha 1;0.01;5,194)} \approx 3.11$	0.83	< 0.01	0.65;< 0.01
	run test with 2nd order polynomial;					
$(S)_{poly.}$	2.44	<	$F_{(\alpha 1;0.01;5,194)} \approx 3.11$	0.83	0.05>P>0.025	0.66;< 0.01
(WS)	2.65	<	$F_{(\alpha 1;0.01;5,169)} \approx 3.12$	0.79	0.025>P>0.01	0.67;< 0.01
(POA)	1.12	<	$F_{(\alpha 1;0.01;4,60)} = 3.65$	0.20	>0.25	0.07; 0.04
(SOA)	0.57	<	$F_{(\alpha 1;0.01;4,64)} \approx 3.60$	0.06	>0.25	0.05; 0.08
(IBA)	0.41	<	$F_{(\alpha 1;0.01;4,59)} \approx 3.65$	0.67	>0.25	0.01; 0.55
(MA)	10.35	>	$F_{(\alpha 1;0.01;2,35)} \approx 5.27$	0.56	< 0.01	0.10; 0.06

Hospital Point

	$F_{(ratio)}$ test	$F_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	3.09 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	not tested	0.1>P>0.05	0.01; 0.49
(UW)	3.43 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.31	0.1>P>0.05	< 0.01;0.85
(WET)	1.45 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.47	0.25>P>0.1	< 0.01;0.84
(S)	5.48×10^{-5} <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.43	>0.25	0.50;< 0.01
(WS)	0.22 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.04	>0.25	0.43;< 0.01
(POA)	1.44 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.91	>0.25	0.05; 0.16
(SOA)	0.64 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.97	>0.25	0.04; 0.23
(IBA)	2.33 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.84	0.25>P>0.1	0.07; 0.10
(MA)	0.51 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.26	>0.25	0.02; 0.41

South Tumon Bay

	$F_{(ratio)}$ test	$F_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	1.36 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.76	P=0.25	0.08; 0.08
(UW)	0.80 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.41	>0.25	0.02; 0.38
(WET)	1.33 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.31	>0.25	0.03; 0.33
(S)	0.27 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.89	>0.25	0.35;< 0.01
(WS)	0.39 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.21	>0.25	0.43;< 0.01
(POA)	0.02 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.70	>0.25	0.06; 0.14
(SOA)	0.04 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.72	>0.25	0.02; 0.39
(IBA)	0.04 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.22	>0.25	< 0.01;0.84
(MA)	0.12 <	$F_{(\alpha 1;0.01;1,40)} = 7.31$	0.49	>0.25	0.03; 0.28

Double Reef

	$F_{(ratio)}$		$F_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	0.40	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.88	>0.25	0.05; 0.18
(UW)	0.55	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.36	>0.25	0.03; 0.33
(WET)	0.34	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.77	>0.25	< 0.01;0.93
(S)	0.13	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.12	>0.25	0.73;< 0.01
(WS)	1.13	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.18	>0.25	0.78;< 0.01
(POA)	1.14	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.99	>0.25	< 0.01;0.75
(SOA)	1.59	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.97	0.25>P>0.10	< 0.01;0.99
(IBA)	0.36	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.91	>0.25	< 0.01;0.65
(MA)	0.09	<	$F_{(\alpha 1;0.01;2,35)} = 5.27$	0.56	>0.25	< 0.01;0.58

Suva Reef

	$F_{(ratio)}$ test		$F_{(ratio)}$ critical	P(V)	P(rep. t.o.f.)	r^2;P(reg.)
(BD)	3.22	<	$F_{(\alpha 1;0.01;4,56)} \approx 3.65$	0.96	0.025>P>0.01	0.46;< 0.01
(UW)	1.34	<	$F_{(\alpha 1;0.01;4,56)} \approx 3.65$	0.15	>0.25	0.51;< 0.01
(WET)	0.58	<	$F_{(\alpha 1;0.01;4,56)} \approx 3.65$	≈0.01	0.25>P>0.1	0.51;< 0.01
(S)	5.85	>	$F_{(\alpha 1;0.01;4,56)} \approx 3.65$	0.12	< 0.01	0.74;< 0.01
run test with 2nd order polynomial;						
$(S)_{poly.}$	1.07	<	$F_{(\alpha 1;0.01;3,56)} \approx 4.13$		>0.25	0.81;< 0.01
(WS)	6.58	<	$F_{(\alpha 1;0.01;4,56)} \approx 3.65$	0.23	< 0.01	0.75;< 0.01
run test with 2nd order polynomial;						
$(WS)_{poly}$	2.38	<	$F_{(\alpha 1;0.01;3,56)} \approx 4.13$		0.10>P>0.025	0.81;< 0.01
(POA)	3.33	<	$F_{(\alpha 1;0.01;4,56)} \approx 3.65$	0.24	0.025>P>0.01	0.68;< 0.01
(SOA)	2.04	<	$F_{(\alpha 1;0.01;4,56)} \approx 3.65$	0.24	≈0.01	0.62;< 0.01
(IBA)	2.43	<	$F_{(\alpha 1;0.01;4,54)} \approx 3.65$	0.29	0.10>P>0.025	0.55;< 0.01
(MA)	2.10	<	$F_{(\alpha 1;0.01;4,54)} \approx 3.65$	0.16	0.1>P>0.05	0.39;< 0.01

APPENDIX 4.5

Response of all variables (whole body and skeletal ossicles) to estimated age (using spine pigment band counts) by comparing mean regression significance from 5 populations using $^{+}S_{Y.X}$ $/Y_{(mean)}$. Analyses by least squares linear regressions of 9 morphometric variables omitting the juvenile/sub-adult phase, 1-3 years for: Davies Reef outbreak (1988-91); Guam - Hospital Point, South Tumon Bay and Double Reef (1992); and Suva Reef (1992). Age was estimated using the spine pigment band ageing method in all adult individuals. Listed equations in table denotes there was a significant increase in the variable throughout the range of estimated age.

	Davies Reef	Hospital Pt.	Sth. Tumon	Double Reef	Suva Reef	$S_{Y.X}$(mean)
(BD) whole body diameter (cm)						
	$r^2<0.01$;	$r^2=0.01$	$r^2=0.08$	$r^2=0.05$	$r^2=0.02$	
	P=0.79;n=166	P=0.49;n=40	P=0.08;n=40	P=0.18;n=35	P=0.45;n=31	
	$S_{Y.X}$=0.107	$S_{Y.X}$=0.100	$S_{Y.X}$=0.092	$S_{Y.X}$=0.097	$S_{Y.X}$=0.117	$S_{Y.X(mean)}$=0.103
(UW) underwater weight (g)						
	$r^2<0.01$	$r^2<0.01$	$r^2=0.02$	$r^2=0.03$	$r^2=0.09$	
	P=0.64;n=80	P=0.85;n=40	P=0.38;n=40	P=0.33;n=35	P=0.10;n=31	
	$S_{Y.X}$=0.268	$S_{Y.X}$=0.181	$S_{Y.X}$=0.213	$S_{Y.X}$=0.245	$S_{Y.X}$=0.303	$S_{Y.X(mean)}$=0.242
(WET) whole wet weight (g)						
	$r^2<0.01$	$r^2<0.01$	$r^2=0.03$	$r^2<0.01$	$r^2=0.12$	
	P=0.53;n=166	P=0.84;n=40	P=0.33;n=40	P=0.93;n=35	P=0.06;n=31	
	$S_{Y.X}$=0.287	$S_{Y.X}$=0.270	$S_{Y.X}$=0.296	$S_{Y.X}$=0.259	$S_{Y.X}$=0.342	$S_{Y.X(mean)}$=0.291
(S) spine ossicle length (mm)						
	$r^2=0.45$	$r^2=0.50$	$r^2=0.35$	$r^2=0.72$	$r^2=0.25$	
	P< 0.01;n=166	P< 0.01;n=40	P< 0.01;n=40	P< 0.01;n=35	P< 0.01;n=31	
	$S_{Y.X}$=0.071	$S_{Y.X}$=0.068	$S_{Y.X}$=0.068	$S_{Y.X}$=0.057	$S_{Y.X}$=0.092	$S_{Y.X(mean)}$=0.071
	S=2.83*A+16.5	**S=2.99*A+7.28**	**S=2.68*A+8.88**	**S=2.08*A+12.72**	**S=1.31*A+15.75**	
(WS) whole spine appendage length (mm)						
	$r^2=0.41$	$r^2=0.43$	$r^2=0.43$	$r^2=0.80$	$r^2=0.22$	
	P< 0.01;n=150	P< 0.01;n=40	P< 0.01;n=40	P< 0.01;n=35	P< 0.01;n=31	
	$S_{Y.X}$=0.079	$S_{Y.X}$=0.080	$S_{Y.X}$=0.081	$S_{Y.X}$=0.056	$S_{Y.X}$=0.109	$S_{Y.X(mean)}$=0.081
	WS=4.60*A+24.9	**WS=4.13*A+9.6**	**WS=5.40*A+6.3**	**WS=3.61*A+15.0**	**WS=2.16*A+22.9**	
(POA) primary oral ossicle weight (adjusted*) (g)						
	$r^2<0.01$	$r^2=0.05$	$r^2=0.06$	$r^2<0.01$	$r^2=0.16$	
	P=0.84;n=69	P=0.16;n=40	P=0.14;n=40	P=0.76;n=35	P=0.03;n=31	
	$S_{Y.X}$=0.242	$S_{Y.X}$=0.239	$S_{Y.X}$=0.217	$S_{Y.X}$=0.173	$S_{Y.X}$=0.221	$S_{Y.X(mean)}$=0.218

(SOA) secondary oral ossicle weight (adjusted*) (g)

$r^2=0.01$	$r^2=0.04$	$r^2=0.02$	$r^2< 0.01$	$r^2=0.12$	
P=0.44;n=59	P=0.23;n=40	P=0.39;n=40	P=0.99;n=35	P=0.06;n=31	
$S_{Y.X}=0.257$	$S_{Y.X}=0.263$	$S_{Y.X}=0.259$	$S_{Y.X}=0.255$	$S_{Y.X}=0.244$	$S_{Y.X(\text{mean})}=0.256$

(IBA) inter-brachial ossicle weight (adjusted*) (g)

$r^2< 0.01$	$r^2=0.07$	$r^2< 0.01$	$r^2< 0.01$	$r^2=0.05$	
P=0.95;n=68	P=0.10;n=40	P=0.84;n=40	P=0.65;n=35	P=0.26;n=30	
$S_{Y.X}=0.293$	$S_{Y.X}=0.248$	$S_{Y.X}=0.268$	$S_{Y.X}=0.229$	$S_{Y.X}=0.247$	$S_{Y.X(\text{mean})}=0.257$

(M) madreporite ossicle weight (adjusted **) (g)

$r^2< 0.01$	$r^2=0.02$	$r^2=0.03$	$r^2=0.01$	$r^2=0.02$	
P=0.83;n=48	P=0.41;n=40	P=0.28;n=40	P=0.58;n=35	P=0.45;n=29	
$S_{Y.X}=0.406$	$S_{Y.X}=0.391$	$S_{Y.X}=0.381$	$S_{Y.X}=0.373$	$S_{Y.X}=0.334$	$S_{Y.X(\text{mean})}=0.377$

Therefore ranked $S_{Y.X(\text{mean})}$ = **S** > **WS** > **BD** > **PO** > **UW** > **SO** > **IB** > **WET** > **M**

where:

r^2 = coefficient of determination
P = probability of regression significance
n = sample size
$S_{Y.X}$ = standard error of estimate
$S_{Y.X}/Y_{(\text{mean})}$ = (standard error of estimate) / ($Y_{(\text{mean})}$) indicates the accuracy which regression predicts the dependence of Y on X).

* total ossicle number related to arm number therefore weight adjusted for the number of arms per starfish.

** madreporite weight adjusted for total number of madreporites according to each individual.

APPENDIX 4.6. Assessment of life-history characteristics from the von Bertalanffy growth equation using: whole body diameter (BD), spine ossicle length (S), whole wet weight (WET) and underwater weight (UW) as growth variables from five populations from the Western Pacific region.

Analyses of growth in variables and estimated age for estimation of life history coefficients were conducted using the von Bertalanffy equation in the form:

$L_t = L_\infty$ x (1 -

where L_t = size of growth variable at age (t) (month)
L_∞ = asymptotic growth variable
K = growth constant ($month^{-1}$)
t_0 = correction factor for the early phase of slow growth, a preliminary plot of growth data showed that $t_0 \approx$ 10mo. and this value was used consistently through the analyses.

APPENDIX 4.6A

Whole body diameter (BD)

Davies Reef (pre-outbreak cohorts)

Parameters	SE	$t_{(0.01(2)51)} \approx 2.67$	P
L_∞ = 44.39	1.886	23.54	< 0.01
K = 0.0415	0.0114	3.64	< 0.01

Analysis of curve model significance

Curve fit	SS	DF	MS	F	P
Curve	48.32	1	48.32	2.781	0.10 < P < 0.25
Error	886	51	17.37		
Total	934.3	52			

$MSE_{(curve)} = 17.37$; $r^2 = 0.05$.

Curve fit ANOVA was not significant, therefore the ***K*** and L_∞ parameters are considered to be not reliable.

Davies Reef (post-outbreak cohorts)

Parameters	SE	$t_{(0.01(2)189)} \approx 2.60$	P
L_∞ = 42.20	0.7142	59.09	< 0.01
K = 0.0510	0.0039	15.07	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	7093	1	7093	363.6	< 0.01
	Error	3687	189	19.51		
	Total	10780	190			

$MSE_{(curve)} = 19.51$; $r^2 = 0.66$.

Hospital Point (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$\mathbf{L}_\infty = 23.69$	0.7659	30.93	< 0.01
$K = 0.1426$	0.1089	1.31	0.05 < P < 0.10

Analysis of curve model significance

Growth curve parameter not significant

South Tumon Bay (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$\mathbf{L}_\infty = 29.41$	2.2920	12.83	< 0.01
$K = 0.0632$	0.0217	2.91	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	25.97	1	25.97	4.39	0.025 < P < 0.05
	Error	224.8	38	5.916		
	Total	250.8	39			

$MSE_{(curve)} = 5.916$; $r^2 = 0.10$.

Curve fit ANOVA was only weakly significant, therefore the K and $\mathbf{L}_\infty$ parameters are considered to be not reliable.

Double Reef (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$\mathbf{L}_\infty = 31.13$	1.097	28.38	< 0.01
$K = 0.0690$	0.0119	5.78	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	477.9	1	477.9	35.3	< 0.01
	Error	514.5	38	13.54		
	Total	992.4	39			

$MSE_{(curve)} = 13.54$; $r^2 = 0.48$.

Suva Reef (Fiji)

Parameters	SE	$t_{(0.01(2)72)} = 2.65$	P
$L_\infty = 34.15$	1.300	26.27	< 0.01
$K = 0.0483$	0.0045	10.70	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	3538	1	3538	241.3	< 0.01
	Error	1056	72	14.66		
	Total	4593	73			

$MSE_{(curve)} = 14.66$; $r^2 = 0.77$.

APPENDIX 4.6B

Spine ossicle length (S)

Davies Reef (combined pre-outbreak cohorts)

Parameters	SE	$t_{(0.01(2)51)} \approx 2.67$	P
$L_\infty = 45.20$	2.378	19.01	< 0.01
$K = 0.0225$	0.00316	7.12	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	253.7	1	253.7	44.25	< 0.01
	Error	292.4	51	5.732		
	Total	546	52			

$MSE_{(curve)} = 5.732$; $r^2 = 0.46$.

Davies Reef (combined post-outbreak cohorts)

Parameters	SE	$t_{(0.01(2)189)} \approx 2.60$	P
$L_\infty = 39.97$	1.2580	31.77	< 0.01
$K = 0.0296$	0.0024	12.32	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	1167	1	1167	207.6	< 0.01
	Error	950.1	169	5.622		
	Total	2117	170			

$MSE_{(curve)} = 5.622$; $r^2 = 0.55$.

Hospital Point (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$L_\infty = 28.98$	3.671	7.89	< 0.01
$K = 0.0275$	0.0067	4.13	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	66.57	1	66.57	36.7	< 0.01
	Error	68.93	38	1.814		
	Total	135.5	39			

$MSE_{(curve)} = 1.814$; $r^2 = 0.49$.

South Tumon Bay (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$L_\infty = 25.14$	2.811	8.94	< 0.01
$K = 0.0382$	0.0099	3.86	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	36.08	1	36.08	20.57	< 0.01
	Error	66.66	38	1.754		
	Total	102.7	39			

$MSE_{(curve)} = 1.754$; $r^2 = 0.35$.

Double Reef (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$L_\infty = 28.61$	1.283	22.30	< 0.01
$K = 0.0330$	0.0035	9.37	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	626.2	1	626.2	250.4	< 0.01
	Error	92.53	38	2.501		
	Total	718.8	39			

$MSE_{(curve)} = 2.501$; $r^2 = 0.87$.

Suva Reef (Fiji)

Parameters	SE	$t_{(0.01(2)70)} = 2.65$	P
$L_\infty = 26.39$	0.9445	27.94	< 0.01
$K = 0.0380$	0.0029	12.98	< 0.01

Analysis of curve model significance

Curve fit		SS	DF	MS	F	P
	Curve	2029	1	2029	491.5	< 0.01
	Error	289	70	4.129		
	Total	2318	71			

$MSE_{(curve)} = 4.129$; $r^2 = 0.88$.

APPENDIX 4.6C

Whole wet weight (WET)

Davies Reef (combined pre-outbreak cohorts)

Parameters	SE	$t_{(0.01(2)51)} \approx 2.67$	P
$L_\infty = 2601$	248.1	10.48	< 0.01
$K = 0.0489$	0.0457	1.07	0.20 < P < 0.50

Analysis of curve model significance

Growth curve parameter not significant

Davies Reef (combined post-outbreak cohorts)

Parameters	SE	$t_{(0.01(2)170)} = 2.61$	P
$L_\infty = 2358$	119.7	19.70	< 0.01
$K = 0.0593$	0.0212	2.80	< 0.01

Analysis of curve model significance

Curve fit	SS	DF	MS	F	P
Curve	2.388×10^6	1	2.388×10^6	5.583	0.025 < P < 0.05
Error	7.273×10^7	170	4.278×10^5		
Total	7.512×10^7	171			

$MSE_{(curve)} = 4.278 \times 10^5$; $r^2 = 0.03$.

Curve fit ANOVA was not significant, therefore the ***K*** and **L_∞** parameters are considered to be not reliable.

Hospital Point (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$L_\infty = 512.2$	55.78	9.18	< 0.01
$K = 0.1015$	0.1615	0.61	> 0.25

Analysis of curve model significance

Growth curve parameter is not significant

South Tumon Bay (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$L_\infty = 987.0$	439.7	2.24	0.01 < P < 0.025
$K = 0.0405$	0.0452	0.90	0.10 < P < 0.25

Analysis of curve model significance

Growth curve parameters are not significant

Double Reef (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$L_\infty = 1453$	248.5	5.85	< 0.01
$K = 0.0361$	0.0160	2.26	$0.01 < P < 0.025$

Analysis of curve model significance

Growth curve parameter is not significant

Suva Reef (Fiji)

Parameters	SE	$t_{(0.01(2)72)} = 2.65$	P
$L_\infty = 2750$	1429	1.92	$0.10 < P < 0.25$
$K = 0.0098$	0.0064	1.53	$0.10 < P < 0.25$

Analysis of curve model significance

Growth curve parameters are not significant

APPENDIX 4.6D

Underwater weight (UW)

Davies Reef (combined pre-outbreak cohorts)

Parameters	SE	$t_{(0.01(2)34)} \approx 2.73$	P
$L_\infty = 189.9$	80.68	2.35	$0.02 < P < 0.05$
$K = 0.0151$	0.0126	1.19	$0.20 < P < 0.50$

Analysis of curve model significance

Growth curve parameters are not significant

Davies Reef (combined post-outbreak cohorts)

Parameters	SE	$t_{(0.01(2)84)} = 2.64$	P
$L_\infty = 115.5$	9.169	12.60	< 0.01
$K = 0.0546$	0.0227	2.41	$0.01 < P < 0.02$

Analysis of curve model significance

Growth curve parameter is weakly significant

Curve fit		SS	DF	MS	F	P
	Curve	3151	1	3151	3.764	$0.05 < P < 0.10$
	Error	70320	84	837.2		
	Total	73470	85			

$MSE_{(curve)} = 837.2$; $r^2 = 0.04$.

Curve fit ANOVA was not significant, therefore the $\boldsymbol{K}$ and $\mathbf{L}_\infty$ parameters are considered to be not reliable.

Hospital Point (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$\mathbf{L}_\infty = 30.05$	4.522	6.65	< 0.01
$\boldsymbol{K} = 0.0926$	0.1056	0.88	$0.20 < P < 0.50$

Analysis of curve model significance

Growth curve parameter is not significant

South Tumon Bay (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$\mathbf{L}_\infty = 55.4$	19.8	2.80	< 0.01
$\boldsymbol{K} = 0.0469$	0.0466	1.01	$0.20 < P < 0.50$

Analysis of curve model significance

Growth curve parameter is not significant

Double Reef (Guam)

Parameters	SE	$t_{(0.01(2)38)} = 2.71$	P
$\mathbf{L}_\infty = 66.12$	9.028	7.32	< 0.01
$\boldsymbol{K} = 0.0457$	0.0186	2.46	$0.01 < P < 0.02$

Analysis of curve model significance

Growth curve parameter is weakly significant

Curve fit		SS	DF	MS	F	P
	Curve	5064	1	5064	17.07	< 0.01
	Error	11280	38	296.7		
	Total	16340	39			

$MSE_{(curve)} = 296.7$; $r^2 = 0.31$.

Suva Reef (Fiji)

Parameters	SE	$t_{(0.01(2)72)} = 2.65$	P
$L_{\infty} = 177.2$	102.5	1.73	0.10 < P < 0.20
$K = 0.0078$	0.0055	1.42	0.05 < P < 0.10

Analysis of curve model significance

Growth curve parameters are not significant